

**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 1:**

***THE INTEGRATED ANALYSIS OF
INVESTMENT PROJECTS***

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ABSTRACT

The goal of a proper project evaluation is to stop bad projects and to prevent good projects from being rejected. This book on *Cost-Benefit Analysis for Investment Decisions* is aimed at helping public officials and private analysts develop and evaluate investment projects to promote economic and social well-being of the country in question. The book proceeds from the formulation and definition of a project to the data requirements for an evaluation, then to the criteria used for accepting a good or rejecting a bad project from both the financial and the economic viewpoints, and finally to the analysis and management of many types of uncertainty faced by various stakeholders. These components are integrated into the analysis in a consistent manner. This chapter contains an overview of the book and of the components of such an integrated appraisal. The forward, table of contents and preface of the book are included with chapter 1.

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COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS

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He is one of the pioneering academicians and professionals in this field. His writings have formed the analytical principles found in the state-of-the-art methodology for applied investment appraisal. He has acted as an economic consultant to many governments and international agencies including serving as the Chief Economic Advisor to USAID for the period 2005-2010. He is a Member: National Academy of Sciences of the U.S., Fellow: American Academy of Arts and Sciences, Fellow: Econometric Society, President: Western Economic Association (1989-90), Vice President: American Economic Association (elected for 1992) President: American Economic Association, 1997, Distinguished Fellow: American Economic Association, 1999

FOREWORD

Few published works have histories as long or as convoluted as this book. It all began with the awakening of my interest in cost-benefit analysis and applied welfare economics during my own graduate studies (1946-49) at the University of Chicago. This interest was nurtured by work in Latin America (starting in 1955) sponsored by USAID and its predecessor ICA, and in India starting in 1961-62 under the sponsorship of MIT's Center for International Studies in collaboration with India's cabinet-level Planning Commission. Out of these experiences came a series of professional papers which formed the background of a graduate course in Project Evaluation at the University of Chicago starting in 1965. Many of these papers were collected in my book, Project Evaluation, first published in 1972 and currently available as a Midway Reprint from the University of Chicago Press.

Glenn P. Jenkins took that course as a graduate student, and almost immediately began to put it to practical use. Even while still a graduate student he consulted on these matters with branches of the government in his native Canada. He continued these Canadian exercises during his appointment as Assistant Professor of Economics at Harvard University, culminating in a year of leave from Harvard, working with the Canadian Government's Ministry of Industry, Trade, and Commerce and its Department of Regional Economic Expansion. Chun-Yan Kuo was a member of the team which evaluated a number of important Canadian government projects at that time. I, too, was involved with these Canadian entities at that time and subsequently, but in the meantime was also accumulating cost-benefit experience in Colombia, Panama, the Philippines, Spain and Uruguay, as well as at the World Bank where I served steadily with its

teaching arm, the Economic Development Institute, from 1962 through the 1960s and most of the 1970s.

Professor Jenkins's Harvard appointment evolved into a senior position with the Harvard Institute for International Development. His first foreign assignment in this role was to Malaysia, where his first task was to give a full-length course in economic project appraisal, under the sponsorship of the National Institute for Public Administration and the Economic Planning Unit of the prime minister's office. This course was very well received, so much so that Jenkins was asked to develop a manual on the subject, following the main lines of that course. It was in the resulting monograph that my name first appeared, placed there by Jenkins in an act of pure kindness, recognizing the role of my Chicago graduate course in the development of his own subsequent thinking. In the mid-1980s the resulting manuscript began to be used as the main text of an intensive summer course (for participants from developing countries) that HIID offered, under Professor Jenkins's direction.

Our separate collaborations with the Canadian government continued, nearly always dealing with project evaluation and often overlapping (i.e., with the two of us working jointly on a given problem). This phase of our work reached something of a climax when Jenkins was appointed Assistant Deputy Minister (ADM) of Finance in Canada's government, a post he held from 1981 to 1984. During this period I consulted regularly with the Department of Finance as well as with other branches of the Canadian government. In some of these activities, Kuo, then a senior Department of Finance official, also collaborated. It was in this period that I first learned that I had been (since 1977) the co-author of this manual. And it was here that I first began to actually participate in successive revisions of and additions to the book's text. On completing his service as ADM, Professor Jenkins returned to Harvard, and soon started the HIID course

referred to above. I ended up making brief appearances in this course every single year. More important, perhaps, was a tradition that developed of my staying on for a week or so after each of these visits, in order to work jointly with Professor Jenkins, continuously editing and updating one part or another of the book. Out of these sessions, and of other work that each of us was doing in other contexts and/or under other auspices, many new ideas were incorporated as time went by. Among them were the analyses connected with distributional weights, the concept of basic needs externalities, the formalization of stakeholder analysis and the introduction of the notion of a shadow price of government funds.

Perhaps the story of one such new idea is worth telling in detail. Around 1998 Professor Jenkins, Kuo and I were contracted by the World Bank and the bi-national commission in charge of the project to undertake a certain component of the research needed for the evaluation of a major bridge project, a planned linkage of Argentina and Uruguay, across the Rio de la Plata, going between the cities of Buenos Aires and Colonia. Our job was to advise concerning the so-called “national parameters” of the two countries. What were the relevant opportunity costs of capital in Argentina and Uruguay? What about the corresponding opportunity costs of foreign exchange? And, finally, of labor? It was in pursuing the economic opportunity cost of foreign exchange that we ran into a snag. The almost-standard way of handling this question seemed straightforward enough. The project authority was assumed to go into the foreign exchange market and buy the necessary divisas (say, dollars) using local currency (say, pesos). As we pursued this standard model in one of our post-course sessions in Cambridge, we found that it was not consistent with a full general equilibrium of the economy. The new demand for foreign exchange was assumed to arise because of an increased demand for tradable goods. As a result the real price of the dollar would rise, and with it the price level of tradables. Hence the supply

of tradables would increase. But the rise in the price level of tradables would stimulate the demand for nontradables, the output of which would then also increase. Increases in the output of both tradables and nontradables did not jibe with economic theory (except under conditions of recession or depression) so something was wrong.

As we tried to resolve this paradox, we found that the “standard” analysis suffered from a missing link. It did not incorporate the way in which the pesos were raised, which were then to be spent on tradables. The raising of these pesos (presumably in the capital market) would displace both consumption and investment, and hence reduce the demand for both tradables and nontradables. Starting from this reduced demand for both, one could then contemplate the demand for both of these aggregates increasing, thus resolving our paradox. No paradox was present in both tradables and nontradables increasing if we measured these moves from a position where both had been reduced from their starting position. This end result laid bare the fact that the whole idea of an economic opportunity cost of foreign exchange was not a stand-alone concept. This concept had a natural and unavoidable twin, which we called the shadow price of nontradables outlays, and which we from that point on built into our book’s analysis.¹ This concept captured the economic costs involved when money was raised in the capital market and spent on nontradable goods or services. It performed exactly the same function as the economic opportunity cost of foreign exchange, differing only in that it traced a scenario where the spending was on nontradables rather than tradables.

¹There had been earlier writings which sensed the underlying problem, but none in which its solution was fully developed. See Blitzer, Dasgupta and Stiglitz (1981) and Jenkins and Kuo (1985) . The joint work outlined above is described in detail in Harberger & Jenkins (eds.) Cost-Benefit Analysis (“Introduction,” pp. 1-72). See also Harberger, Jenkins, Kuo and Mphahlele, “The Economic Cost of Foreign Exchange in South Africa,” South Africa Journal of Economics, 2004 and Harberger “Some Recent Advances in Economic Project Evaluation,” Cuadernos de Economia, 2003 (v. 40, no. 120), pp. 579-88.

The evolution of the book continued, but it was occurring too slowly, even for our own satisfaction. This led to our inviting Chun-Yan (George) Kuo to join us as a third co-author. Professor Kuo had been associated with the Harvard program from its inception, and had continued his affiliation with it when it was moved to Queen's University after HIID's untimely demise. With his addition to the team, the preparation of the manuscript for publication advanced more rapidly, bringing us to the present moment.

I close this preface on a personal note. Beyond Jenkins's generosity in making me a co-author some five years before I knew about it, I ended up being the beneficiary of coming first, as our names appeared in alphabetical order. I always felt this left readers with an inadequate appreciation of the extent of Professor Jenkins's role. He was the sole writer of the initial version of the book, and the sole director of the course whenever it was given, whether at Harvard, or at Queen's, or in any of the numerous other venues in which versions of varying lengths were presented over the years. These other versions include numerous presentations at the World Bank, the African, Asian, and Inter-American Development Banks, plus multiple presentations in Argentina, Azerbaijan, Bolivia, Chile, Indonesia, Malaysia, Nicaragua, Philippines, South Africa, Sri Lanka, Thailand and Uruguay.

For the final published version of the book, I therefore insisted that Professor Jenkins's name come first. I promised to write this foreword in order that readers would have a reasonably clear understanding of our respective roles.

Arnold C. Harberger

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PREFACE

This book on Cost Benefit Analysis for Investment Decisions represents a culmination of work in this field by its authors over a period of more than 40 years. Many of our colleagues and students have played important roles as the intellectual contents of this text were developed. Those who have made specific contributions during the long gestation of this manuscript include Ernesto Fontaine, Alejandra Cox-Edwards, Donald Tate, Savvakis Savvides, Graham Glenday, M. Baher El-Hifnawi, G.P. Shukla, Vijdan Korman, Andrey Klevchuk, Pradip Ghimire and Aygul Ozbaflı.

The preparation of this book has been guided by two main objectives. First, the approach must be firmly rooted in the disciplines of finance and economics, and structured to reflect the principles of these disciplines. Second, that it must address the practical needs of analysts faced with evaluating a broad gamut of real-world public and private sector projects.

This book has evolved over time through its use as the core reading material in the Program on Investment Appraisal and Management that was initiated at Harvard University in 1984, and that since 2000 has been offered at Queen's University in Canada. Through that program and many shorter courses taught to groups around the world, thousands of professionals have been trained in this discipline using various earlier drafts of this book as their primary teaching materials. Alumni of this program have used these same earlier drafts to train thousands more in universities and government institutions around the globe. As a result of these experiences, we have gained many insights and have introduced many improvements dealing with real-world applications of the principles outlined in the text. Hence, this book is designed

so that it can be used both in the classroom as a reference manual and to help professionals apply the principles of investment appraisal in a wide array of settings and sectors.

Earlier versions of this text have been used in several dozen programs taught to enhance the professional development of the staff of multilateral financial institutions, including the World Bank, the African Development Bank, the Asian Development Bank, the Inter-American Development Bank and the Caribbean Development Bank. Recently, the World Bank has provided generous funding to modify the basic training materials so as to make them more applicable for the analysis of infrastructure projects with private sector participation. This interaction has contributed to our thinking and in particular to reinforcing the importance of making this text directly relevant for the development professionals who need to apply the principles of cost-benefit analysis to real world decisionmaking.

It is not easy to summarize the many ways in which this book differs from other texts and/or manuals on cost-benefit analysis. In part it still bears some marks of its origin in an economic graduate course. Even though this aspect has been toned down over the years, it delves more deeply into issues of concept and methodology than do most cost-benefit texts. Moreover, it quite consciously builds on the long tradition of applied welfare economics, as it was developed by a series of great economists going from Adam Smith to David Ricardo to Jules Dupuit, John Stuart Mill, Alfred Marshall, Vilfredo Pareto, Harold Hotelling, and James Meade, down to the present time. It is from this great tradition that economists learned how to quantify the gains from trade and the costs of monopoly, to evaluate policies such as price controls, export subsidies, agricultural support programs and the like. These results, plus many others developed in the 200-odd year evolution of applied welfare economics, emerged from a rigorous,

disciplined application of economic principles. There is nothing casual or ad hoc about this great tradition.

We have consciously and constantly strived, in developing the materials in this book, to remain faithful to this tradition. In seeking answers to new questions we have tried always to base our work on economic fundamentals. Any measure of benefits and costs over time must be expressed in real terms, but cannot plausibly be carried out “at constant prices of a given base year”. It is a basic economic truth that there is great economic benefit in the act of taking copper bars from the ongoing economy when their price is one real dollar per pound, and returning them to the economy when it values them at three real dollars per pound (so long as the real opportunity cost of capital is covered). But then we must find a way of defining the real dollar that is capable of capturing such movements in relative prices. That role is played in economic theory by choosing one price or price index as what we call the numeraire, our basic unit of measurement. We face this choice and conclude that the only two reasonable candidates for a numeraire are a country’s consumer price index and its GDP deflator. With the first of these we measure all benefits and costs in “consumer baskets”; with the second our measurement is done in “producer baskets”.

The mere fact that we have to have a numeraire has important implications for the discount rate to be used in project analysis. The project starts with our extracting purchasing power from the rest of the economy; the payback comes later as the project yields its benefits over time. The question is, of course, are these benefits worth the costs that were entailed as purchasing power was extracted in order to do the initial investment? Economic logic and rigor require that both the extraction of resources and the subsequent benefit flows be evaluated in the same units -- in our case either in consumer baskets or in producer baskets. So what about the

discount rate? In the process of extracting resources we displace either investment or consumption that would otherwise have taken place, and possibly also draw some new capital funds from abroad. On the displaced investment the economy loses the future flow of earnings that it would have yielded; on the displaced consumption (which means increased saving), the economy suffers a loss unless the savers earn a rate of return covering the “supply price” of these savings. Thus fundamental principles of applied welfare economics tell us that the economy has suffered a loss unless a project yields benefits sufficient to cover the lost productivity (from displaced investment) plus the genuine economic supply price of any newly-stimulated savings, plus the marginal cost (to the economy) of the funds drawn in from abroad. The project, in order to be worth while, has to generate benefits (translated into numeraire units) sufficient to cover the costs (also expressed in numeraire units) that were entailed in raising the investment resources in the first place.

Then comes the question, what is the mechanism by which these resources are raised? Investment and consumption can be displaced by new taxes, but which taxes? Each new tax law is different from the last, which makes the choice of a standard or typical tax package arbitrary. Moreover, we would hardly ever be able to link the funds from a particular project to a particular tax package.

Once again, economic fundamentals come to the rescue. The capital market (which in some poor countries is simply the banking system), is in fact the “sponge” which absorbs any net new funds the government might have in any day, week or month. The capital market can also be relied on to generate the purchasing power to cover any current cash deficit or shortfall. The capital market is thus truly the government’s marginal source and use of funds. Typically, when expenditures end up bigger than expected, the government borrows more. When receipts turn

out to be unexpectedly high, it borrows less (and sometimes pays down its outstanding debt). There is a big added dividend to the use of the capital market as the standard source of funds, since it is typically the source of private sector funds as well. Hence the economic opportunity cost of capital is derived from an essentially similar scenario, regardless of whether the investment is being done by the private or the public sector.

The methodology of cost-benefit analysis applies quite easily and naturally to commercial-type ventures (whether private-sector, public-sector or joint between the two) whose costs and benefits consist overwhelmingly of cash outlays and cash receipts. But what do we do with benefits and costs that are not in this form? The answer here is a bit complicated. Some non-cash benefits and costs can be quantified by direct application of economic analysis. Thus we have economic studies that estimate the value that commuters place on the time they spend going to and from work, and the costs involved in ships waiting in line to enter a port or canal, and the value that recreational users place on their visits to parks, museums, etc. Then we have other benefits which can be set by the analysts themselves (in the absence of other instructions) or by public sector authorities attempting to put values on particular non-market goals. In this vein we have values denoting “society’s” willingness to pay for added fulfillment of the basic needs of the poor, or for added economic activities in a given region or industry. Finally, we have a range of areas in which neither of the previous answers can plausibly apply. National defense benefits and those linked to a nation’s culture, history and traditions come to mind here. For these the standard answer of professional economists is that we have little or no claim of professional expertise in setting values on such elements. Instead, we try to quantify those items which we are professionally equipped to estimate, and derive measures of costs and benefits for just those items. We then confront our audiences with statements like “In this project, the direct

economic costs exceed its direct economic benefits by \$200 million. We leave it to the authorities to decide whether its national defense or other non-quantifiable benefits are worth this cost.”

In addition to its heavy reliance on economic fundamentals, this volume emphasizes what we call an integrated analysis of projects. In this aspect we incorporate financial and stakeholder analyses in addition to a strictly economic one. The clearest motivation for our doing so is the fact that many projects which have the potential to be highly beneficial in strictly economic terms run into trouble because they face difficulties on the financial or the stakeholder side. The financial analysis is central in the sense that it tries to capture all the relevant financial flows connected with a project. Far too often, evaluators will neglect such items as routine maintenance and repair, or recurrent expenditures for insurance, record-keeping or supplies. Financial analysis can also call attention to situations in which particular outlays are dependent on fragile and unreliable sources of funds -- sometimes on state budgetary items that are subject to capricious fluctuations from year to year or from administration to administration. Finally, the financial analysis, by setting down all of a project’s outlays and receipts (usually in a spreadsheet format), establishes a solid basis for the subsequent economic analysis, helping to ensure that it provides comprehensive coverage.

The stakeholder analysis is also related to the financial one, but in a different way. Many projects require collaboration, or at least tacit acceptance, from a number of stakeholder groups, if the projects are to succeed, or perhaps even if they are to get started. Agricultural projects depend on the contributions of farmers, truckers, middlemen and perhaps exporter interests. Regional development projects require willing help from experts from outside the region. Projects to enhance medical service in rural areas often founder because of the reluctance of

experienced physicians to relocate there. The function of the stakeholder analysis is to see to it that provision is made, within the framework of the project, to ensure that each critical group of stakeholders has an adequate incentive to carry out its required role.

In addition to presenting the methodologies that apply to the general financial, stakeholder and economic analyses, this volume deals with a number of particular types of projects that are commonly encountered in developing countries -- e.g., those dealing with transportation, electricity, potable water and irrigation. The relevant chapters are mainly devoted to exploring the specific aspects which set these classes of project apart from others. Of particular importance here is the quantification of benefits in cases where they are not captured by a market price, or in which the relevant prices are not good measures of the corresponding benefits. These chapters can serve as roadmaps guiding analysts through the landscape that is special for each class of project. These general roadmaps are supplemented in most cases by examples drawn from actual real-world project evaluations in the area in question. These are presented in summary form with the intention of focusing on the particular activities that give each type (e.g., roads, dams, electricity systems) its special characteristics.

Finally, in an appendix to this book, we make available a number of problem sets that have been used over the years in university courses based on the book's material.

CHAPTER 1

THE INTEGRATED ANALYSIS

1.1 Introduction

The goal of a proper project evaluation is to stop bad projects and to prevent good projects from being rejected. This *Book on Cost-Benefit Analysis for Investment Decisions* is aimed at helping public officials and private analysts develop and evaluate investment projects to promote economic and social well-being of the country in question. The book proceeds from the formulation and definition of a project to the data requirements for the evaluation, then to the criteria used for accepting a good or rejecting a bad project from both the financial and the economic viewpoints, and finally to the analysis and management of many types of uncertainty faced by various stakeholders. These components are integrated into the analysis in a consistent manner.

Ideally, government investment expenditures should be in the public interest. Such expenditures can be in the form of government investment, public-private partnership arrangements or other forms of government intervention. This implies that resources should not be reallocated from the private to the public sector unless such a move is likely to make residents better off. In situations where private investments are being undertaken with financial support from either governments or development finance institutions it is important to know the financial viability of such activities. Financial failure often leads to a contingent liability coming due at the expense of a public body. For an activity with contingent liabilities to be undertaken in the first place, it should be clear that its economic benefit exceeds its economic cost. Regulations impose both investment and operating costs largely on the private sector with the hope of either creating or preserving benefits for the people. Many developed country governments now require that cost-benefit analyses be undertaken to evaluate regulatory interventions. In each of these situations, account must also be taken of how the benefits and costs of these actions are distributed among the relevant stakeholder groups. These themes will be addressed under the headings of the financial, economic, and stakeholder analyses of what we refer to here as simply a “project”.

By their very nature investment projects offer uncertain benefits and costs over life of the project. Even a project's investment costs are often subject to overruns due to technical difficulties and delays in implementation. These uncertainties must be taken into account in the course of a project's evaluation. Risk analysis and how to reduce risk through the use of contracts are thus basic elements of the integrated project evaluation framework developed in this book.

Some public sector projects or programs such as healthcare and education may not be properly assessed using the standard framework of cost-benefit analysis because of difficulty in quantifying their benefits in monetary terms. This book will show how the evaluation of such projects or programs can be handled, using the techniques of cost-effectiveness analysis.

1.2 The Targeted Users of the Book

This book is intended for a variety of users. First, it serves as a guide to these in finance and planning ministries, national government treasuries budget bureaus and even line ministries such as public health, energy and necessary who are responsible for making public sector investment decisions. In short it addresses the needs of any group involved with the formulation, evaluation and implementation of projects. Second, the book is provided to educate the private investment community on the economic and social aspects of investment appraisal. Third, it provides a methodology that can help to taxpayers as well as to international development and lending institutions to be confident that the money allocated for public investments will be spent in a responsible and productive way. Fourth, the book contains theoretical developments and practical applications to real world cases that will be of interest to the academic community.

With such a wide audience, the book has to be comprehensive yet not get bogged down in abstract theory or complicated calculations and technical refinements. Thus, we have tried to present the theory underlying our analysis in a clear and accessible fashion, yet without bypassing important details. Similarly, we have tried to choose our real-world cases in such a way that they both illustrate how basic principles should be applied, and at the same time guide practitioners through the steps that must take in carrying out real-world applications.

1.3 Project Definition

Public investments are key policy instruments used by governments in pursuing their overall development goals and strategies. The chosen projects should fit into the overall development strategy given the limited resources that are available. In principle, governments should maintain a running list of potential projects, out of which priorities for further evaluation and eventual construction should be continuously selected.

1.3.1 Definition of a Project and Building Blocks for Evaluation

In capital budgeting, a project is the smallest, separable investment unit that can be planned, financed, and implemented independently. This helps to distinguish a project from an overall objective that may consist of several inter-related investments. Often projects form a clear and distinct portion of a larger and less precisely identified objective or program. While it is possible to treat an entire program as a project for the purposes of analysis, it is far better to work with individual projects. Broad programs very likely will contain both good and bad components. It is precisely the task of project evaluation to identify and select those with the greatest positive impact.

The principles and methodology set forth in this book can be applied to the full range of projects - - from single-purpose activities such as small infrastructure projects to more complex multi-component systems such as integrated rural development and area development schemes. Our basic definition considers a project to be “any activity that involves the use of scarce resources during a specific time period for the purpose of generating a socio-economic return in the form of goods and services”.

After a project’s objectives and scope are defined, a number of key modules should be identified. This will include the project’s market and competitors, the technology and inputs required for the project, and how the project is likely to be financed.

- a) Demand Module: This identifies the likely users of the project’s output as well as the likely valuation of its products. Are the products destined for domestic use or for sales abroad? Are there alternative sources capable of meeting the likely demand? The analysis should initially be based on secondary research, but may also involve consultations with potential users and beneficiaries. The expected volumes and unit values over the life of the project

should be examined and forecasted. The information identified provides the basic data for a profile of the project's costs and benefits, while the breakdown between tradable and nontaxable purchases and sales is needed in order to separately apply the relevant exchange rate to the foreign part. Analysts must make serious efforts to incorporate in their work the likely future trends of relative prices -- real exchange rates, relative product prices, real wage rates, etc.

- b) **Technical Module:** This module examines the technical feasibility of the project's investment and operating plans, alternative project scales, location, as well as timing of the project's implementation. Technical parameters should be separately determined and clearly laid out for each of the investment and operating phases. In the process, engineering data in terms of inputs by type (machinery, equipment, and material), quantity, cost, and time of use should all be specified. In the case of manpower requirements, the type of skill, number, and expected real wage rate should also be determined. Project analysts should also identify potential bottlenecks for key project inputs, especially workers with particular skills. This information will provide the basic construction and operation cost year by year over the life of the project, i.e., the project's profile.

For certain projects, it is important to identify any technological uncertainties. In such cases, some guarantees from the suppliers should be sought and incorporated in the evaluation. In addition, one should identify a number of project sizes and associated inputs or costs estimated by technical or engineering experts. This information will help project analysts to identify a project with the optimal scale and timing.

- c) **Project Financing:** The possible sources of debt and equity financing for the project should be examined since the terms of financing can have a significant impact on the financial viability of a project. Where borrowed funds are involved, the amount of debt, interest rates, and repayment schedules should all be spelt out and closely examined. Alternative schemes of financing such as Build-Operate Transfer (BOT) may be contemplated in certain cases.

1.3.2 Project as an Incremental Activity

An important element in the investment appraisal is to examine the incremental impact of the project; that is how net receipts, net cash flows or net economic benefits with the project in the presence of the project under study can be expected to differ from those that would prevail in its absence. One should make the with/without distinction clearly and carefully so as not to include in the “with-project” scenario any benefits or costs that would exist “without” the project being undertaken. The “without project” situation does not mean that nothing is done to the current situation if the project is not undertaken. In principle it is a sort of moving picture of how the relevant items and markets would naturally evolve if the project were left aside, but with “good” decisions being taken on all other (non-project) matters at each step.

In this context, one should conceptualize two states of nature: one with the project and the other without the project. The former identifies the revenues and expenditures associated with the case in which the project is undertaken, while the latter refers to all relevant benefits and costs that would likely prevail if the project were not undertaken. Comparing the two, a project usually involves incremental net expenditures in the construction phase followed by incremental net benefits in the operating phase. The incremental net cash flow (or net economic benefits) refers to the net of benefits minus outlays that occur with a project less the corresponding figure that would have occurred in the absence of the project. In this way, we would properly identify the additional net benefit flow that is expected to arise as a result of a project. And from it, the corresponding change in economic well-being that is attributed to it can be measured.

1.4 An Integrated Approach

Traditional approaches to investment appraisal have tended to carry out a financial analysis of a project completely separated from its economic evaluation. The integrated project analysis developed in this book measures benefits and costs in terms of domestic prices for both the financial and the economic appraisal. Identification is then made of the stakeholder impacts among parties. Since project costs and revenues are spread over time, uncertainty becomes an issue and is first dealt with in the financial analysis. Its consequential effects are then assessed in the economic analysis. In what follows, we present an overview of how an investment project is evaluated through an integrated financial, economic, risk and stakeholder analysis.

1.4.1 Financial Appraisal

The financial analysis of a project inquires whether the project is financially viable. It is a cornerstone of many capital investment projects. The requirements for data and the assessment of the commercial viability are briefly outlined below.

A. Data Requirements

The module starts with the projection of the volumes of output, inputs, and deliveries that constitute the principal financial flows of a project. It then proceeds to generate the financial cash flow statement of the project by taking into consideration, where relevant, such items as accounts receivable, accounts payable, and changes in cash balances. The final result will yield the expected flows of financial receipts, financial outlays, and hence the net cash flow of the project period by period over its life.

In forecasting benefits and costs over the life of the project a key decision concerns whether to work exclusively with real (i.e., inflation-corrected) magnitudes, or whether to carry out some of the analysis in nominal terms, before converting them to real terms. In this book, we follow the principle of always carrying out the economic analysis in real terms, and it usually (though not necessarily) doing the financial analysis in nominal terms. The guide as to whether this book exercise should be performed is whether key elements exist (like nominal debt, nominal tax components, or nominal rental contracts) that are fixed in advance in nominal terms, and whose conversion to real terms thus varies under different assumed future inflation rates.

The data on benefits should identify whether they accrue domestically or abroad. Correspondingly, expenditures on each item (including machinery, equipment, and material inputs) should also be separated according to whether or not it is internationally traded. The breakdown is important for analysing foreign exchange implications in the economic appraisal. In the case of manpower requirements, it is essential to classify labor by occupation and skill type in order for a proper estimate of the economic opportunity cost of labor to be obtained.

Project financing may also be a key variable for the commercial viability of a project. Its debt/equity structure and the terms of interest rates can have an impact on tax liability and cash

available to cover its costs. Thus, some reasonable assumptions about these parameters are necessary. In the case of projects with private equity participation, the required market rate of return on such capital will influence the viability of the project from the investor's point of view.

B. Development of Financial Cash Flow Statement

A project's viability is very much determined by the timing of the cash receipts and disbursement. Thus, the projection of these items has to be done carefully so as to alert the analyst in advance to possible periods of illiquidity (or even liquidity crisis) in the future. Items such as accounts receivable, accounts payable, changes in cash balances, prepaid expenses and inventories should all be accounted for in constructing the financial cash flow statement. Yearly tax liabilities (where relevant) should be estimated following the accounting and tax rules of the country where the project is located. Expected future changes in tax and tariff rates should be built into the project profile.

Very often the project will still have assets at its projected closing date. In such a case the likely future (real) market value of such assets should be incorporated as part of the final year's net benefit. Normally, such residual values will be estimated by applying standard real economic depreciation rates for the different asset types.

Once the financial cash flow statement of the project is completed, its potential viability can be assessed. Since the project has different stakeholders who are mainly concerned with their own interests, financial cash flow statements can be generated for each such group. For government-sponsored and government-related projects, a minimum of three financial cash flow statements are usually developed from different viewpoints -- banker's point of view, owner's point of view, and government budget point of view:

- The banker's (or total investment) point of view examines the expected possible receipts and expenditures of a project, considering the investment base to be the sum of equity and debt capital, and the annual cash flow to be the amount available for distribution to both equity holders and creditors.

CHAPTER 1:

- The owner's point of view considers capital outlays to consist only of the owners' (equity) funds. Loans are treated as inflows when they arrive, and amortization payments are treated as outflows.
- From the government budget viewpoint, the government will ensure if the relevant government departments have enough resources to finance its obligations to the project.
- Where a government project is expected to stand on its own, the financial flows accruing to the relevant entity, including receipts from sales, fees charged, plus cash inflows from earmarked taxes or budgetary allocations all count as benefits, but tax revenues changes unconnected with the entity do not appear in the financial analysis (but of course, they are part of the economic analysis of the project).

The financial cash flow statements vary among different points of view. For example, the financial profile from the banker's viewpoint may start with cash flows expressed in current prices. These may then be deflated by the relevant price index to arrive at real values for this profile. Because the banker would like to know if the net cash flow is sufficient to repay the loans from different financing arrangements, his starting point for a credit analysis is the net cash flow from the total investment. Since the bankers' viewpoint looks at the project "as a whole", such as project profile serves as a natural base for the development of the project's economic profile, which also looks at the project as a whole, but includes a wider range of benefits and costs.

The nominal financial cash flow statement from the total investment point of view can be augmented by the proceeds of debt financing but reduced by the interest payments and principal repayments of the loans to obtain the net nominal cash flow from the owner's point of view. These values are then deflated by the inflation price index to determine the cash flow in real prices (as a given year) from the owner's point of view. As the owner or investor of the project, he will be expecting to receive a rate of return on the project no less than his real private opportunity cost (net of inflation) of equity financing. Using this opportunity cost as the discount rate, a private equity owner would expect the discounted net financial cash flow over the life of the project to be greater than zero. This private discount rate would normally cover the risk associated with the operating and financial leverage of the project as well as the risk due to uncertainty.

C. Evaluation Criteria

There are alternative criteria for determining the financial attractiveness of a project. However, the net present value (NPV) of the project is widely accepted as the most satisfactory criterion for the evaluation of project profiles. As such, when a project is being appraised from the viewpoint of equity holders or owners, the relevant cost of funds or discount rate is the return to equity that is being earned in its alternative use. The project will be commercially viable if the present value of the discounted cash flows is greater than zero. If the NPV is less than zero, the investors cannot expect to earn a rate of return equal to its alternative use of funds and thus the project should be rejected.

Other criteria that are also used in the business community include internal rate of return, benefit-cost ratio, its pay-back-period, and its debt service ratio. Each of these measures has its own shortcomings. However, the debt service capacity ratio is often regarded as a key factor in determining the ability of a project to pay its operating expenses and to meet its debt servicing obligations. This measure is particularly relevant when considering a project from the banker's point of view.

The government usually provides key social sector projects or a wide range of services such as healthcare or education. The issues involved in this undertaking tend to generate low or no revenues from the project at all. However, the financial analysis can still be relevant as a framework for presenting the yearly requirement of funds for continuing with the project.

1.4.2 Risk Analysis and Management

The financial analysis and results have so far been based on the deterministic values of project variables. It is, however, highly unlikely that the values of all of a project's key variables such as the rate of inflation, the market exchange rate, and the prices and quantities of inputs and outputs will be projected with certainty throughout the life of the project. Hence a project's net present value and other summary measures are subject to uncertainty and risk. Adapting the analysis to cover uncertainty is thus an important part of an integrated project evaluation.

The first step in conducting a risk analysis of a project is to identify the key risk variables using sensitivity and scenario analysis. The variables chosen should not only represent a large share of relevant benefits and costs but also experience a significant amount of variation in terms of the final outcome. It is usually necessary to focus only on the uncertain variables that contribute to the riskiness of the project in a significant way.

Once the risky variables are identified, the second step is to select an appropriate probability distribution and the likely range of values for each risk variable, based on the past movements of values of the variable and on expert opinion concerning it. The relationships between variables are also important and need to be specified. Monte Carlo simulation is by now a well established device for generating a probability distribution of project outcomes. Such an exercise would end with an expected probability distribution of a project's NPV, based on the underlying uncertainty surrounding each of the key risk variables specified. From this cumulative probability distribution we can read off the probability that the project's estimated NPV will exceed \$1 million, \$10 million or any other given value. We can also derive the expected mean, median, mode, deciles and quartiles of the NPV distribution. With so much uncertainty in a project, a proper project evaluation should provide some assessment of the expected variability of a project's net return, the probability of getting a negative NPV, and how this uncertainty affects the net benefit flows to the key stakeholders.

There are different kinds of uncertainty and risk associated with a project. Uncertainty can be related to suppliers, customers, or project financing. People may view uncertainty and risk differently in terms of their tolerance of risk. Contractual arrangements to manage risk are both a common and an essential component of certain projects. Thus, consideration must be given to redesigning or reorganizing a project to reallocate risk more efficiently. For example, there may be alternative financing arrangements that would help to redistribute some of the risk to a stakeholder who is willing to accept the risk at a low cost to the project and hence make a project more attractive. There may be contracts that project managers can enter into with its customers/end-users or its suppliers. These different arrangements could create incentives or disincentives that would encourage a project's participants to alter their behavior so as to improve the project's overall performance. The effects of such contractual arrangements are an integral part of the appraisal of a project. Monte Carlo simulations can be used to help understand the

nature and magnitude of the variability of the project. They can also be used to measure the impact of different contracts on the variability of the project's outcome.

1.4.3 Economic Appraisal

The economic appraisal of a project deals with the effect of the project on the entire society and inquires whether the project is likely to increase the total net economic benefit of the society, taken as a whole.

A. Rationale and Underlying Assumptions

Economic cost-benefit analysis is an important component of applied welfare economics, a branch of economic science which has steadily evolved over more than 200 years. A great deal of what applied welfare economics has to contribute is based on three simple postulates:

- a) The competitive demand price for an incremental unit of a good measures its economic value to the demander and hence its economic benefit;
- b) The competitive supply price for an incremental unit of a good measures its economic resource cost; and
- c) Costs and benefits are added up with no regard to who are the gainers and losers.

When no distortions are present, the demand price and supply price of a good will coincide, making its economic value clear. But distortions (of which taxes are paramount) are complicating our analysis.

In reality, many distortions prevail in the economy of any country, including among others, personal income tax, corporate income taxes, value-added tax, excise duties, import duties, and production subsidies. These distortions would have a considerable impact on the economic valuation of capital, foreign exchange, and goods or services produced or used in the project in question. They should be properly assessed and incorporated in the economic appraisal.

For example, the benefits of a project's output should be measured by the demand price inclusive of a value-added tax or a general sales tax, rather than the market price received by the project in

the financial analysis. On the other hand, if there is a production subsidy in the project, the resource cost of inputs used in the production should include the subsidy as part of the cost in the economic analysis. Non-tax distortions like air and water pollution also generate external costs, which should be assessed and accounted for in an economic analysis.

Many public projects (e.g., roads and schools) have the outputs that are not sold in an open market. Nonetheless an economic analysis must somehow try to capture and evaluate the total economic benefits of the output of the goods and services generated by these projects.

B. Development of the Economic Resource Statement

Like the financial cash flow profile in the financial appraisal, the economic appraisal needs to reflect all benefits and costs (whether financial in nature or not) and whether they accrue to direct project participants or to other members or entities in the society (including the government).

Goods and services in the economy can generally be classified as internationally tradable and non-traded and they are evaluated differently in the economic appraisal. A good or service is considered internationally tradable if a project's requirement for an input is ultimately met through an expansion of imports or reduction of exports. Conversely, the output produced by a project is a tradable good if its production brings about a reduction in imports or an expansion of exports. Land, buildings, local transport, public utilities and many services are almost intrinsically non-traded. In addition, there are potential tradable goods whose prices are "unhooked" from the world price structure. These include goods that normally would be considered to be internationally traded but are rendered nontraded with particularly high or prohibitive tariffs and also goods that are potentially tradable but whose internal price lies above the FOB export price or below the CIF import price.

For non-traded goods and services, the economic price of a project input or output is based on the impact an additional demand for the input or supply of an output has on the demand as well as the supply of the good in the market. For example, suppose a project increases the production of a good. The additional supply by the project results in a decrease in the market price, which will cause consumers to increase their consumption but make some of the existing producers to cut back their production. The economic benefits produced by the project's output should be

measured by the weighted average of the value of additional consumption enjoyed by consumers, which is the amount consumers are willing to pay (the demand price which is the price inclusive of taxes, if any) and the value of resources released by the existing producers (the supply price or the value inclusive of subsidy but net of taxes). The demand and supply weights are determined by the response of additional demand and the cut back in supply with respect to the reduction in the market price.

By the same token, when a project demands an input, its additional demand will result in an increase in price, which in turn will stimulate the existing consumers to cut back their consumption and induce producers to increase their production. The economic cost of the inputs demanded by the project should be measured by the weighted average of the forgone consumption (valued by the price inclusive of taxes) and the value of resources costing the society (measured by the price excluding taxes but including subsidy, if any). Again, the weights are determined by the response of consumers and suppliers to the change in market price.

Labor is generally considered a non-traded good. However, the economic cost of labor varies by occupation, skill level, working condition, and location, depending upon the project in question.

Once the economic benefits or economic costs are calculated, they replace the values used in the financial analysis for value of receipts or expenditures in the financial cash flow statement. The simple calculations or a conversion factor can be created as the ratio of the economic benefits or costs to its corresponding financial prices of outputs or inputs and then simply multiplying the financial receipts or costs by the corresponding conversion factors to arrive at the economic benefits or costs for construction of the economic resource statement.

In the case of tradable goods, distortions may include customs duties on imported inputs of a project or those imported items that the project output will replace. An export tax or export subsidy on the output of the project is also a distortion and should be accounted in the economic evaluation. In general, the economic prices of these tradable goods are all equal to their border price converted at an exchange rate reflecting the economic opportunity cost of foreign exchange.

There are certain projects in which consumers are willing to pay more than the value of the prevailing market price. In such case, their gain in consumer surplus should be incorporated as an additional economic benefit and reflected in the economic profile of the project. This takes place most often in public sector projects such as enhancement of water supply projects or road improvement projects. On the other hand, there are also projects generating pollution or other negative environmental externalities. In this case, items such as pollution or congestion costs should be evaluated and accounted for in the economic analysis of the project.

C. Evaluation Criteria

Once the economic profile is constructed, the economic discount rate is used to estimate the project's net present value. The relevant discount rate is the economic opportunity cost of capital in the country in question. This hurdle rate applies not only to investments financed solely with public funds but also to the economic evaluation of investments undertaken by the private sector. An economic net present value greater than zero implies that the project is potentially worthwhile. That is, it would generate larger net economic benefits than the normal use of equivalent resources elsewhere in the economy. On the other hand, if the net present value is less than zero, the project should be rejected on the ground that the resources invested could be put to better use if they were simply left in the capital market.

Like the financial appraisal, the Monte Carlo simulations can be used to generate a probability distribution of the net present value of the project.

1.4.4 Stakeholder Impacts

It is important for the sustainability of the project over time to identify the winners and losers and how much they would gain and lose as a result of the project's implementation. The financial and economic analysis of the integrated project analysis will provide the basic data for estimating the specific stakeholder impacts. In the financial analysis, there are several groups or parties affected by a project. Each such group's benefits and costs can be analyzed to determine who gains and who loses as a result of a project. The purpose of this distributional analysis is to see if the benefits of the project will actually go to the targeted groups, as well as to ensure that no specific group is subjected to an undue burden as a result of a project. The magnitude of any burden can

be measured by the present value of the incremental net benefit flows that are expected to be realized by that group. Among the main stakeholders affected by a project are generally the project's suppliers, consumers, project competitors, labor, and the government. The impact on government is mainly derived from the externalities generated by taxes and subsidies.

1.5 Cost-Effectiveness Analysis

The capital investment project has so far been evaluated in the context of a cost benefit analysis. However, there are certain projects in which benefits of the project are difficult to quantify in monetary terms. These projects include health, nutrition, education, water supply, electricity generation, etc. In this case, an alternative approach called cost-effectiveness analysis is commonly employed.

Cost-effectiveness analysis functions by comparing the costs of achieving a given outcome by alternative routes. By simply choosing the lowest cost of achieving a given benefit, it avoids the necessity of placing a monetary value on the benefit. Where the output in question has several dimensions, one can develop an index that places plausible weights on these different aspects (e.g., speed, convenience, accessibility, etc.), and choose that option that yields the lowest cost per index unit. This variant is sometimes called cost-utility analysis.

Once a project is approved, managing and monitoring the progress of the project is important for organizations in terms of time, cost and performance. It requires an establishment of an implementation schedule for the project and progress is assessed against this schedule. The post evaluation focuses on the outcome of the project to see if the economic and social goals of the project are achieved and what are the impacts on stakeholders of the project after its implementation.

1.6 The Organization of the Book

This book consists of 20 chapters. Chapter 2 describes the evolution of project cycle and the links between the various components of a project's development. It starts with the project definition, followed by building blocks and data requirements for appraising projects, and finally integrates the various components into the evaluation framework.

Chapter 3 examines the first major component of the overall evaluation framework: how to perform the financial analysis of a project. The purpose of a financial analysis is to estimate whether the project is financially sustainable, i.e., how will it cover its financial cost expenditures? For projects that have direct participation of the private sector, the question is whether the investors will find the project in their interest. The accuracy of the financial analysis depends heavily on the accuracy of the technical, marketing, and commercial analyses used to construct a project's investment, financing, and operating plans. Accurate estimation of the net present value of the project's net cash flows requires consideration of potential vulnerability to inflation as well as an estimate of the appropriate cost of capital that can serve as the private discount rate.

Project criteria are presented in Chapter 4 including debt service capacity ratios as a measure of a project's sustainability. The dominant criterion used in project evaluation, namely the net present value, is described in detail. This is done against a backdrop of one of the key attributes of any investment project, its time dimension. Net economic benefits must also be discounted or accumulated to a given point in time before they can be added up or otherwise compared. Chapter 5 discusses how a project's NPV helps answer important questions such as the appropriate initiation date, scale, duration, and termination date of a project.

The financial analysis is based on the deterministic value of each of the input and output variables of the project over the life of a project. The actual outcomes, however, are unlikely to be exactly as projected because of the uncertainty in the future over the life of the project. This uncertainty needs to be factored into a project's financial analysis. Chapter 6 introduces uncertainty and risk analysis in the financial appraisal by examining the merits of sensitivity, scenario, and Monte Carlo analysis, with emphasis on the last of these. Measures necessary for dealing with uncertainty, such as different types of contracts and instruments of project financing are presented. The risk analysis also extends to the associated economic and distributional impacts of the project.

Chapter 7 presents the three basic postulates for applied welfare economics. These include the concepts of consumers' and producers' surplus and a definition of the different kinds of economic distortions and externalities. The chapter outlines how the three postulates can be used to estimate

the economic prices of goods and services in the absence, and then in the presence, of distortions. The extension of the financial analysis to incorporate the additional costs and benefits linked to externalities shifts us to an economic framework, focusing on costs and benefits as they affect “society as a whole”.

Since the economic analysis, like the financial analysis, relies on the NPV criterion as the basis for decision making, an economic discount rate is needed to calculate the present values of the net economic benefit streams. Chapter 8 provides the methodology for calculating the economic discount rate. Similarly, an estimation of a shadow price for foreign exchange is needed to reflect the distortions that exist in the tradable goods sector. These distortions are the source of a foreign exchange externality that causes the economic opportunity cost of foreign exchange to differ from the market exchange rate. In addition, a corresponding premium should also be estimated and accounted for expenditures of non-traded goods and services which are influenced by the same externalities that apply to the traded-goods sector in Chapter 9.

The determinations of the domestic price of tradable and non-tradable goods are fundamentally different. Chapter 10 deals with the measurement of the economic price of tradable goods at project sites under various situations. Chapter 11 develops an analytical framework to measure the economic price of non-tradable goods or services when all repercussions of a project output or purchase of project inputs are taken into account.

Chapter 12 examines the economic opportunity cost of the labor involved in a project. The project wage is the financial cost of labor. However, its economic cost, or shadow wage rate, can differ from the financial cost because of various distortions prevailing in labor markets.

The distributional analysis, also known as stakeholder analysis, can be important for the sustainability of a project. One can identify major groups or parties affected by a project when one moves from the financial analysis to the economic analysis. They can be assessed to determine who will benefit and who will lose from the project and by how much. This helps identify and quantify the impacts of a project on various interest groups. This analysis is presented in Chapter 13 and its purpose is to ensure that no specific group is subjected to an undue burden or is presented with an unwarranted benefit as a result of a project.

Chapter 14 deals with two additional issues frequently raised in cost-benefit analysis. One is the shadow price of government funds and how it should be treated in our framework. The other is how distributed weights should be dealt with in the analysis of a project. In its ultimate analysis, poverty is the inability of households or residents to meet the basic needs including health, nutrition, water and sanitation, education and housing. A project that addresses these issues is more valuable to society and should get preference over another project that has the same financial and economic values but does not cater to these special areas. The concept of a basic needs externality and how a project can be given credit for helping the neediest groups in society is addressed in this chapter.

In certain projects, it is rather difficult to quantify benefits in monetary terms. A cost effectiveness analysis becomes a useful and effective criterion to make choices between projects or programs. The description of this concept and application is outlined in Chapter 15.

Applications of the integrated appraisal developed above to specific sectors are illustrated in the following chapters of the book. Chapter 16 deals with various conceptual issues of transportation projects. The focus is on highway projects, including road improvements and newly constructed roads. Externalities connected with road projects as well as those involving rail transport are also discussed in this chapter.

Chapter 17 illustrates how a proposed investment in upgrading a gravel road to a tarred surface in South Africa should be evaluated. This is a project with no toll levied on road users and thus no financial evaluation is carried out. However, from the economic perspective, the evaluation covers not only the assessment of savings in road maintenance costs by the Road Agency but also reduction in vehicle operating costs for road users due to the improvement of road surface, time savings for road users due to the increased speed of vehicles and other fiscal externalities.

Chapter 18 describes the unique features and the problems of electricity investment projects. The principles of the marginal cost pricing of electricity applied to peak and off-peak hours as well as resource cost savings by adopting least alternative generation technologies are particularly relevant to the investment in this sector. The conceptual discussion covers investments in both hydro and thermal electricity generation.

Chapter 19 demonstrates how the least alternative cost principle is applied to the appraisal of a project aimed to expand the capacity of the electricity generation system in Adukki. A single cycle thermal plant was originally proposed to be built and operated by an Independent Power Producer (IPP) while the state utility is the only off-taker of the electricity generated by this plant. The price paid to the IPP is negotiated through a long term Power Purchase Agreement. This chapter illustrates how a comparison of the financial and economic outcomes of the plant can be made with those of a combined cycle plant.

The last chapter, Chapter 20, applies the integrated investment approach to an assessment whether an investment program to upgrade the water and sewer utility in Panama is financially and economically feasible and sustainable. Estimates of the gross economic benefits or costs of the additional or reduced consumption of water are all based on the well-established welfare economics principles outlined in previous chapters. Nevertheless, the stakeholder analysis of this chapter causes concerns regarding the potential excess profits that could be received by a foreign concessionaire under the terms of the proposed concession.

The economic and social development of any country depends on the selection of sound investment projects. This book provides a theoretical and practical framework for project development and evaluation. It facilitates the preparation and assessment of projects to ensure that good projects get implemented while bad projects are stopped. Both decisions promote the economic and social well-being of the residents of the country in question.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 2:**

*A STRATEGY FOR THE APPRAISAL OF
INVESTMENT PROJECTS*

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ABSTRACT

Every project has certain phases in its development and implementation. The appraisal stage of the project cycle should provide information and analysis on a range of issues associated with the decision making of the project. First, the administrative feasibility of project implementation must be fairly assessed and the marketing and technical appraisals of the project must be provided to evaluate its feasibility. Second, the financial capability of the project to survive the planned duration of its life must be appraised. Third, the expected economic contribution to the growth of the economy must be measured based on the principles of applied welfare economics and a series of assumptions used to undertake this appraisal. Finally, an assessment must also be made to determine if, and how, this project assists in attaining the socio-economic objectives set out for the country, along with an analysis to determine if this project is cost-effective in meeting these objectives. This chapter describes how this appraisal functions is carried out with the framework of project cycle.

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CHAPTER 2

A STRATEGY FOR THE APPRAISAL OF INVESTMENT PROJECTS

2.1 Introduction

Every project has certain phases in its development and implementation. The appraisal stage of the project cycle should provide information and analysis on a range of issues associated with the decision making of the project. First, the administrative feasibility of project implementation must be fairly assessed and the marketing and technical appraisals of the project must be provided to evaluate its feasibility. Second, the financial capability of the project to survive the planned duration of its life must be appraised. Third, the expected economic contribution to the growth of the economy must be measured based on the principles of applied welfare economics and a series of assumptions used to undertake this appraisal. Finally, an assessment must also be made to determine if, and how, this project assists in attaining the socio-economic objectives set out for the country, along with an analysis to determine if this project is cost-effective in meeting these objectives.

To carry out this task while offsetting some of the biases inherent in project appraisal requires a level of professionalism on the part of the analyst which is difficult or impossible to attain if project appraisal is carried out on ad-hoc basis. For the appraisal of projects in the public sector, a corps of project evaluators must be developed within the government in order to attain a level of project appraisal that will significantly improve overall project planning and selection. These evaluators should not only be aware of country's political environment but also have a general sense that their mission is to provide an accurate assessment of a project's viability based on professionally determined criteria.

Often there is a tendency to examine the financial (or budgetary), economic and distributional (or stakeholder) impacts of a project or program as three independent outcomes. These three aspects of the overall performance for a project are, however,

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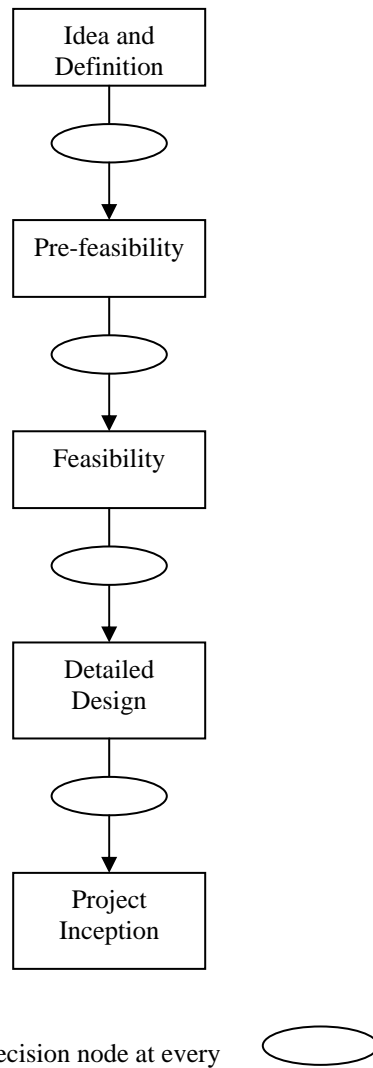
generally closely inter-related and should be viewed as three parts of an integrated evaluation. For example, the distributional impact of a project can not even be estimated without information on the financial and economic appraisal. Similarly, its economic efficiency can be impaired if it can not rely on the project's revenues or planned budgetary allocations needed for it to operate effectively.

The economic, financial, and stakeholder analysis of a project should also be closely linked because the information obtained at one stage of the appraisal may be essential for the completion of another aspect of the evaluation. For example, if we wish to know how much unskilled labor is benefiting from a project we must first know their wage rates and the numbers employed by this project. Such information is generally reported in the work sheets required to prepare the financial analysis of the project. If we wish to measure the impact of the project's pricing policy on the welfare of a particular group of people, the basic information on the project's customers and their relative consumption of the project's output will be found in the marketing module, that is required for the financial appraisal of the project.

A preliminary analysis of a public sector project that looks at financial variables alone is not very meaningful, no matter how accurately it has been carried out. The appraisal will be of more value to the public sector decision-makers if the analytical effort is spread out over all the important aspects of the project to derive its impact on the net economic well-being to society as a whole.

The identification, appraisal, and design phase of a project's development is composed of a series of appraisals and decision points leading to either the inception or rejection of the project. This process can logically be divided into four stages of appraisal and four decision nodes before the project receives final approval. These stages can be shown diagrammatically as in Figure 2.1.

Figure 2.1
Stages in Project Appraisal and Approval



2.2 Idea and Project Definition

The first and most important task of every procedure for project evaluation is to ensure that the prospective benefits of a project exceed its prospective costs. This is by no means a simple and straightforward task. In practice, it typically takes place in a sequence of stages (see Figure 2.1), each involving more time and resources than its predecessor, and as a

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consequence (one hopes) developing a more accurate picture of the project's likely costs and benefits. To be approved, a project should surmount each of the successive hurdles. A rejection, on the other hand, can take place at any stage. Some projects are so bad that their gross inadequacies are shown up even by the very roughest initial screening. Other, less bad projects, tends to be screened out in the pre-feasibility phases. The later stages of feasibility and detailed design may give rise to the rejection of some projects, but are more likely to be concentrated on such elements as the precise tuning and scale of the project, the specific design and determination of its components, etc.

Issues of design as well as other aspects of project strategy often involve much more than the simple quantification of a project's likely total costs and benefits. The way in which these costs and benefits are distributed can also weigh heavily in determining its feasibility. Many projects involve numerous different groups of stakeholders. For example, for an irrigation project there are farmers, regional and local governments, the highway authority and highway users, the owners and residents of land to be flooded, the downstream users of the river's water, etc. While it may be that the project could be brought to fruition over the opposition of one or more of such groups, it is clearly wiser for the sharing of benefits and costs to be arranged in such a way as to leave most of them content. Indeed, no project will get underway unless it is designed (including the way costs and benefits will be shared) so that every stakeholder group that has some sort of "veto power" is precluded from exercising that power.

Financial issues can also come into play in many different forms. Stories are rife concerning beautiful, modern hospitals whose facilities are largely wasted because of inadequate budgets for doctors' and nurses' salaries, for equipment and for medicines. Electricity systems that started in fine shape have fallen into disrepair and failed to bring the expected benefits because lagging adjustments of tariffs to inflation have impeded proper maintenance and have rendered it impossible to borrow to keep capacity in line with the growing demand. Road projects entailing large capital investments financed by borrowing have similarly ended up failing to deliver their expected benefits, owing to financial shortfalls that

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precluded adequate maintenance and repair. In just about all these cases there was no intrinsic deficiency in the project itself; instead, some sort of institutional rigidity was at fault. But experience tells us that it is the job of a wise project appraisal process to try first to foresee and then to forestall such financial difficulties.

It should be clear from the above that in cases where stakeholder interests play a significant role, and/or where the viability or success of a project is vulnerable to avoidable financial contingencies, these elements should be taken into account at each successive stage of the appraisal process. It is not prudent to leave them to be dealt with, almost as an afterthought, only at or near the final stage. This is why we, in this book, have tried to present an appraisal that permits the analyst to focus on economic, financial, and stakeholder considerations within a substantially integrated framework.

2.3 Pre-Feasibility Study

The pre-feasibility study is the first attempt to examine the overall potential of a project. In undertaking this appraisal, it is important to realize that its purpose is to obtain estimates that reflect the right “order of magnitude” of the variables in order to roughly indicate whether the project is attractive enough to warrant more detailed design work.

Throughout the appraisal phase and, in particular, at the pre-feasibility stage, estimates which are clearly biased in one direction are often more valuable than mean estimates of the variables, especially when these latter are only known with significant uncertainty. In order to avoid acceptance of projects based on overly optimistic estimates of benefits and costs, the pre-feasibility analysis should use estimates with a downward bias for benefits and an upward bias for costs. If the project still looks attractive even in the presence of these biases, then it stands a good chance of passing a more accurate evaluation.

The pre-feasibility study of any project will normally cover six different areas. These can be summarized as follows:

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- a) *Demand module* in which the demand for the goods and services, and prices, or the relative needs of social services are estimated, quantified, and justified.
- b) *Technical or Engineering module* in which the input parameters of the projects are specified in detail and cost estimates developed.
- c) *Manpower and administrative support module* in which manpower requirements are specified for the implementation as well as for the operation of the project and sources of manpower identified and quantified.
- d) *Financial/Budget module* in which the financial expenditures and revenues are evaluated along with an assessment of the alternative methods of financing.
- e) *Economic module* in which the project's economic costs and benefits as a whole are appraised from the viewpoint of the economy.
- f) *Environmental Assessment module* in which the various environmental impacts of the project are identified, evaluated and proposals developed for their mitigation.
- g) *Stakeholder module* in which the project is appraised from the point of view of who receives the benefits and who pays the costs of a project. Where possible, quantification should be made to determine by how much each of these groups benefits or pays.

Whenever possible, the pre-feasibility study should utilize secondary research. Secondary research examines previous studies on the issues in question and reviews the specialized trade and technical journals for any important data that may be relevant to the appraisal of the project. Utilization of the research on commodities and technical aspects of projects from institutions or associations disseminating pertinent information is essential. Most technical and marketing problems have been faced and solved before by others. Therefore, a great deal of information can be obtained quickly and cheaply if the existing sources are utilized efficiently.

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a) Demand Module

The demand module should be thought of as a first attempt at serious quantification of the benefits of the project. If the output of the project is directly marketed (like telephone services), the module may consist of projecting the likely time path of its economic price (in real terms), and estimating the quantity demanded along that price path at each point in time. If the project provides a service (like highway services), that might but need not be subject to a user charge, the appropriate procedure is to go directly to an economic evaluation of benefits and costs in real terms, and then consider whether user charges are appropriate, how high they should be, and how they should be administered. In such cases, the willingness to pay of the beneficiaries is a key element in the estimation of benefits, even though total benefits may differ significantly from estimated toll collections. At the other extreme, there are projects in which the estimated user-demand plays little or no role. Typically in these cases, the value of the product of the project is established in other ways. Sometimes the value of the “output” of the project is seen by all substantially exceed its cost. In these cases resort is made to a fundamental economic principle: one should not attribute to any project a benefit that is greater than the cost of the least-cost alternative way of achieving the same result. Often in such cases a “standard” alternative exists (for example, thermal electricity generation in the case of electricity), whose costs are easily determined. Then the benefit of “our” project would be considered to be the saving of costs that it provides, as against the costs of the “standard” alternative.

For the demand analysis of tradable goods, the key variables are the prospective levels and likely trends of their prices, relative to the domestic price level (and to that of tradable goods generally). Here one can often find market analyses by the relevant producer associations and professional experts with projections of prices and world output.

For the demand analysis of a product to be sold in the domestic market, it will be more important to begin primary research at the pre-feasibility stage of the project appraisal. The analysis will need to assess the overall marketing plan of the organization undertaking the project. The potential users of that product will often have to be surveyed before an accurate

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picture of its potential demand can be determined. If the product is to be sold in a competitive environment, then a judgment should be made as to how the competitors in the market are likely to react. Such a judgment can be based on reviews of past actions, as well as the institutional strengths and weaknesses of the competitors. Ultimately, the demand for the project's output will depend on the nature of the product, the competitive advantages of the project in supplying the product and the resources spent to market the output.

In the case of public monopolies such as public utilities, government policies themselves may be important in determining the demand for the output. Extension of electricity supply to new rural areas and the development of new industrial complexes can have an important bearing on the future demand. The growth in the demand for the output of a public utility can often be projected accurately by studying the relationship over time of demand with respect to variables such as disposable income, industrial output, household formation and relative prices. The study of growth in demand experienced by utilities in other countries with similar circumstances can also help to provide a good basis for projecting future trends.

The output of this module, if it is to be a commercial project, should be a set of forecasts of the following variables for the duration of the project:

- 1) Quantities of expected "output" of the project as well as the time path of associated real benefits.
- 2) Quantities of expected sales and prices for goods to be sold domestically and not in competition with internationally traded goods.
- 3) Sales taxes and export taxes that are expected to be paid on the project's output of the traded goods.
- 4) Sales taxes to be paid on goods not traded internationally.
- 5) Subsidies to be received on the basis of production, sales, exports, etc.
- 6) Government regulations (such as price ceilings and floors, or quotas), affecting the sales or price of the output.

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- 7) Product trends in terms of technological developments and the expected product cycle.
- 8) All trade restrictions that are not created by government regulation must be identified and their impact should be quantified.

b) Technical or Engineering Module

In this module, secondary research can be used very effectively. Engineering firms and technical experts in a field usually have considerable experience in other projects that have used either identical technology or similar techniques. Often there are many consulting firms or government agencies that have technical expertise in a specific area. The most important rule to follow when using outside expertise in assisting with feasibility studies, is that the consulting group being employed to provide this information must be informed that it will not be considered for the design or management of the facility in the design and implementation phase. It is critical to avoid placing the consultants used in the appraisal of a project in a position where they have a conflict of interest. Consultants should be hired at the appraisal stage to provide truthful information based on their experience in the past. The authorities also may wish to indicate to them that if their estimates for the current project prove to be accurate then they will receive favorable attention when the contracts are being let on future design activities of other projects. The consultants used to assist in the preparation of the appraisal should also be retained to check and approve the design and cost estimates developed by the group that has been given the task of preparing the final detailed plans.

If this procedure is not followed then there will be a conscious effort on the part of the engineering or technical consultants to underestimate costs in order to get the project approved. Once the project is approved, they get an opportunity to obtain the more profitable task of preparing a detailed design of the project. Of course, the worst possible approach is to ask for free advice at the appraisal stage on the basis that the outside experts will be given a chance to do further work for hire if the project is attractive. It is a sad commentary on the

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performance of many governments in this area to note that these last two procedures are the ones often followed.

The output from the technical module of a pre-feasibility study should obtain the following information:

- 1) The quantities of inputs by type which will be required for the construction of the project.
- 2) The likely time paths of the real prices of these inputs and their probable sources of supply.
- 3) The time paths of the labor requirements of the projects, for each occupation and each category.
- 4) The physical input requirements for the operation of the project by year and by volume of output.
- 5) The likely sources of supply for these inputs and the assumptions on which the time paths of their future real prices are based.
- 6) Information on the technological life of the project.
- 7) The nature and extent of the impacts that the project is expected to have on the environment.

c) Manpower and Management Module

Project appraisal, to be effective, must not confine itself to examining the financial and economic costs and benefits under the assumption that the project can be built and delivered operationally and on time. This assumes a degree of management capacity that simply does not exist in many situations. Many projects have failed because they were undertaken without making sure the management and administrative expertise was available to be able to deliver the project as specified.

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This module must reconcile the technical and management requirements of the project with the supply constraints on manpower available to this project. If they cannot be reconciled, then the project should not be undertaken. A careful study of the labor markets should be made in order to ensure that the estimates of expected real wage rates to be paid are soundly based and that the planned sources of manpower are reasonable in the light of labor market conditions.

In general, manpower requirements should be broken down by occupational and skill category and these needs should be evaluated in terms of the possible sources from which they might be met. Where difficulties are foreseen, this information should be passed to the technical module so that possible revisions of the timing of the project can be considered.

d) Financial/Budget Module

The financial/budget module provides the first integration of the financial and technical variables that have been estimated by the previous modules. A cash flow profile of the project will be constructed which will identify all the receipts and expenditures that are expected to occur during the lifetime of a project. Even in the pre-feasibility stage, an attempt should be made to provide a description of the financial flows of the project that identifies the key variables to be used as input data in the economic and stakeholder appraisal.

Initially, the financial cash flows will be expressed in terms of nominal prices overtime because certain key variables such as taxes and debt repayments are calculated in terms of their nominal values. These nominal values are then converted into their real value equivalents by dividing by a numeraire price index. It is usually necessary to examine a project financed performance over time in terms of the real values of the financial variables in order to determine its financial robustness over time and, hence, its financial sustainability.

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Because of the need for estimates of particular variables (e.g., foreign exchange requirements) for the purpose of making economic and stakeholder project appraisals, the level of financial detail required is considerably greater than what is usually found in the financial appraisal of a private sector project. The financial module should answer a series of basic questions concerning the financial prospects and viability of the project. Four of the most important of these questions are outlined below:

- 1) What relative degrees of certainty do we place on each of the revenue and cost items in the financial analysis? What factors are expected to affect these variables directly and in what way?
- 2) What sources of financing will be used to cover the cost of the project? Does this financing have special features, such as subsidized interest rates, grants, foreign equity or loans?
- 3) What is the minimum net cash flow required by this investment to be able to continue operations without unplanned requests being made to the government treasury for supplementary financing?
- 4) Does the project have a large enough net cash flow or financial rate of return for it to be financially viable? If not, what sources of additional funds are available and can be committed to assist the project if it is economically and socially justified?

If any one of these questions points to future difficulties then adjustments should be made in either the design or financing of the project to avoid failure.

e) Economic Module

This module attempts to cover the full benefits and costs of a project in society or the economy, as flows through time, expressed in real terms.

The distinction is made between the benefits and costs of the project as seen by the “project owner” and those perceived by “the economy as a whole”. Here one is concerned with such

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items as taxes, subsidies and other distortions flowing between the government and the project, with benefits that accrue to the project's users (in the form, say, of consumer surplus), and with externalities like pollution and congestion, where costs are borne by people other than their specific perpetrators. Typically, a financial analysis will incorporate only the financial flows accruing to or paid by the project. Thus, the key questions are outlined below:

- 1) What are differences between financial and economic values for each of the important variables? What causes these differences?
- 2) With what degrees of certainty do we know values of these differences?
- 3) What is the expected value of economic net benefits?
- 4) What are the probabilities for different levels of net economic value being realized?

f) Environmental Impact Assessment Module

The environmental impact assessment module brings together the information from both the demand module and the technical module to assess the likely environmental impact of the project and to determine the most cost-effective ways of mitigating the negative impacts. The analysis undertaken in this module in many instances should quantify the physical impacts of the project on the environment and attempt to measure the economic costs and benefits of these impacts. In the assessment of the negative impacts there is a need to consider the trade-offs that might exist between the benefits arising from the project and the environmental damage that is likely to occur. The alternatives and their economic cost for controlling the environmental damage should be compared to the economic cost of the damage that will be incurred. When the environmental costs are uncertain but have the potential of inflicting significant damage, other alternative ways of supplying the good or service that do not have the same potential for inflecting the environmental costs must to be evaluated as alternatives to the project under consideration.

In the cases where the benefits or costs (and damages) cannot be quantified but the impacts are considered significant, they should be listed, substantiated and properly documented in

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the analysis. For those intangible or qualitative items, they may have significant impacts on decision-making.

g) Stakeholder Module

The stakeholder analysis is concerned with the identification and wherever possible, the quantification of the impacts of the project on the various stakeholders. These include the impact of this project on the well-being of particular groups in society, since seldom does a project benefit everyone in a country proportionally. Political factors should be identified as well as long-run impacts of the project on the community, which are not reflected by the changes in income. While this aspect of the appraisal may be less precise than the financial or economic analysis of a project, the stakeholder evaluation should be tied to the same project factors that are expected to reduce poverty or address the basic needs of poorer members of the community.

An illustrative set of questions to be asked by the analyst when undertaking a stakeholder appraisal of a project is as follows:

- 1) Who are the beneficiaries of this project and who is expected to bear the costs?
- 2) In what ways do those who benefit from the project receive those benefits and how do those who bear the costs pay?
- 3) What other political or social impact is this project expected to generate? How?
- 4) What are the basic needs of the society that are relevant in the country? What impact will the project have on basic needs?
- 5) By what alternative ways (and at what costs) could the government obtain social results similar to those expected from this project (or program)?
- 6) What are the net economic costs of undertaking these alternative projects or programs? How do their costs compare with those incurred by the project in order to achieve the same political or social objectives?

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In evaluating the social impact of a project, there are two important principles that should be remembered. First, the reasoning should be clear as to how this project is going to produce the social impacts attributed to it. Secondly, as the government is usually undertaking many projects and programs to reach its social objectives, we must compare the cost-effectiveness of this project with, at least, a benchmark of the costs which are incurred by the other policy instruments available. Only if this project is as cost-effective as other projects and programs in achieving the social objectives, should an additional benefit be attributed to it.

The set of questions, which have been outlined for a financial-economic-social appraisal of a project, makes it clear that it is our aim to categorize costs and benefits from the point of view of society as a whole. However, we should recognize that some costs and benefits will be financial and directly generated within the project, and others will be financial but external to the project. We should also emphasize that some costs and benefits will be measurable and valued at an imputed price, and others will be identifiable but measured and/or valued with some degree of uncertainty. The variety of types of costs and benefits should be borne in mind in interpreting the results of a social project appraisal. In particular, we should not be misled by the apparent simplicity of the net economic or social present values expressed as real numbers.

2.4. Feasibility Study

After completing all the modules of the pre-feasibility study, the project must be examined to see if it now shows promise of meeting the financial, economic, and social criteria that the government has set for investment expenditures. A sensitivity analysis must be made on the project to identify the key variables which determine its outcome.

The function of the feasibility stage of an appraisal is to improve the accuracy of the measures of key variables if this particular project indicates it has a potential for success. In order to improve the accuracy, more primary research will have to be undertaken and perhaps a second opinion sought on other variables.

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The important risk variables that affect the project's performance need to be identified. The methods of risk reduction, allocation and management need to be developed and applied to the identified risk variables as part of the feasibility study.

It is at the end of this stage that the most important decision has to be made as to whether the project is financially attractive to all interested parties in activity and if it should be approved. It is much more difficult to stop a bad project after the detailed (and expensive) design work has been carried out at the next stage of appraisal. Once sizable resources have been committed to prepare the detailed technical and financial design of a project, it takes very courageous public servants and politicians to admit that it was a bad idea.

2.5 Detailed Design

After the feasibility study, if the decision-makers give their approval to the project, then the next task being is to develop a detailed project design and make detailed arrangements for financing the project. Preliminary design criteria must be established when the project is identified and appraised but usually expenditures on detailed technical specifications are not warranted at this time. Once it has been determined that the project will continue, the design task should be completed in more detail. It involves setting down the basic programs, allocating tasks, determining resources and setting down in operational form the functions to be carried out and their priorities. Technical requirements, such as manpower needs by skill type should be determined at this stage. Upon completion of the blueprints and specifications for construction of the facilities and equipment, then the operating plans and schedules along with contingency plans must be prepared and brought together in the development of a formal implementation plan.

In summary, the detailed design stage of a project appraisal is the point where the accuracy of the data for all the previous modules is improved to the point where an operational plan of action can be developed. Not only is the physical design of the project completed at this stage, but so is the program for administration, operating, and marketing.

When this process is completed, the project is again reviewed to see whether it still meets the criteria for approval and implementation. If it does not, then this result must be passed on to the appropriate authorities for rejection.

2.6 Project Implementation

If the appraisal and design have been properly executed then the selection of the project for implementation should only entail the completion of negotiations to finalize the conditions for financing and the formal approval of the project. The formal approval will require the acceptance of funding proposals and agreement on contract documents, including tenders and other contracts requiring the commitment of resources.

The implementation of a project involves the coordination and allocation of resources to make the project operational. The project manager will have to bring together a project team including professionals and technicians. This team will in turn have to coordinate the various consultants, contractors, suppliers and other interested agencies involved in putting the project in place. Responsibility and authority for executing the project must be assigned. This will include the granting of authority to make decisions in areas related to personnel, legal and financial matters, organization and administration. Proper planning at this stage is essential to ensure that undue delays do not occur and that proper administrative procedures are designed for the smooth coordination of the activities required for the implementation of the project.

The appointment of a project manager means that responsibility for implementation will fall within his or her jurisdiction. This will involve decisions regarding the allocation of tasks to groups within the organization and decisions regarding the procurement of equipment, resources and manpower. Schedules and time frames need to be established. Control and reporting procedures must be activated to provide feedback to policy makers and the project manager.

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When the project nears completion preparation must be made for phasing out of the construction activities and hand over to the new operational management. The project completion will necessitate a scaling down and dismantling of the project organization. A transfer of project personnel and equipment to other areas of the operation will be required. These activities may occur over a considerable period of time. However, as the project becomes operational it is essential that the skills, plans and controlling organization be available to carry on with the function of the project in order to avoid excessive start up costs which can easily undermine the overall success or failure of the project.

2.7 Ex-Post Evaluation

In the short history of formal cost benefit analysis or project appraisal considerably more effort has gone into the pre-evaluation of projects than into the review of the projects actually implemented. For the development of operational techniques of project appraisal it is essential to compare the predicted with the actual performance of projects. In order that this review of the strengths and weaknesses of implemented projects be of the maximum value to both policy makers and project analysts it is important that some degree of continuity of personnel be maintained within the organization's project evaluation teams through time.

In carrying out this evaluation a review of the administrative aspects of the project development should be made immediately after the project becomes operational. The managers of the operational phase of the project must be made aware of the fact that an in-depth evaluation of the project's performance is to be carried out through time. In this way the necessary data can be developed through the normal financial and control activities of the operation to enable an evaluation to be carried out at minimum cost.

The ex-post evaluation helps not only to assess the performance of a project and to give an ultimate verdict on its contribution to the country's development but also to identify the critical variables in the design and implementation of a project that have contributed to its success or failure. The ex-post evaluation helps an organization to repeat the successful experiences and to eliminate the failures.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 3:**

THE FINANCIAL APPRAISAL OF PROJECTS

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ABSTRACT

The financial analysis of a project helps determine the financial viability and sustainability of the project. Since the integrated project analysis begins with the financial analysis and then the economic analysis, the concepts and data ought to be organized in a consequential and consistent manner. The comparison of either financial or economic benefits with their corresponding costs requires that all relevant data should be organized into a project profile covering the duration of the project's life. While a project profile is given by cash flows in the financial appraisal, the project's profile in the economic appraisal provides a flow of net economic benefits generated by the investment. This chapter explains how cash flow profiles of a project are developed and constructed in a consistent fashion. It also discusses how investment project can be evaluated from different points of view.

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CHAPTER 3

THE FINANCIAL APPRAISAL OF PROJECTS

3.1 Introduction

The financial analysis of a project helps determine the financial viability and sustainability of the project. Since the integrated project analysis begins with the financial analysis and then the economic analysis, the concepts and data ought to be organized in a consequential and consistent manner. The comparison of either financial or economic benefits with their corresponding costs requires that all relevant data should be organized into a project profile covering the duration of the project's life. While a project profile is given by cash flows in the financial appraisal, the project's profile in the economic appraisal provides a flow of net economic benefits generated by the investment. This chapter explains how cash flow profiles of a project are developed and constructed in a consistent fashion. It also discusses how investment project can be evaluated from different points of view.

3.2 Why a Financial Appraisal for a Public Sector Project?

It may appear that the financial appraisal of a project is of interest only to a private investor who wishes to determine the net financial gain (or loss) resulting from the project. Because public sector projects utilize public funds the analysis from the public perspective is primarily concerned with the project's impact on the country's economic welfare. From a country's prospective, a project should be undertaken if it generates a positive net economic benefit. A project that yields negative net economic benefits should not be undertaken as it will lower the economic welfare of society as a whole. To determine the net economic benefits produced by a project the appraisal of such projects needs to incorporate an economic analysis.

There are several reasons for also conducting a financial appraisal for a public sector project. The most important one is to ensure the availability of funds to finance the project through

its investment and operating phases. While an expected positive economic return is a necessary condition for recommending that a project be undertaken, it is by no means a sufficient reason for a successful outcome. A project with a high expected economic return may fail if there are not enough funds to finance the operations of the project. Many examples of development projects with expected high economic returns have failed due to financial difficulties. Water supply projects are typical examples of projects that generate substantial economic benefits due to the large economic value attached to water, but receive little financial revenues because of the low water tariffs. If the project is undertaken solely on the basis of the favorable economic analysis with no consideration to the financial sustainability, the project may fail due to lack of funds to maintain the system and service its debt. Other examples include projects such as public transport and irrigation where services are usually provided at concessional prices.

A financial analysis enables the project analysts to establish the financial sustainability of the project by identifying financing shortfalls that are likely to occur over the life of the project, thereby being able to devise the necessary means for meeting these shortfalls. A key objective of a financial appraisal for a government project is to determine whether the project can continue “to pay its bills” throughout its entire life; and if not, how can the shortfalls be met.

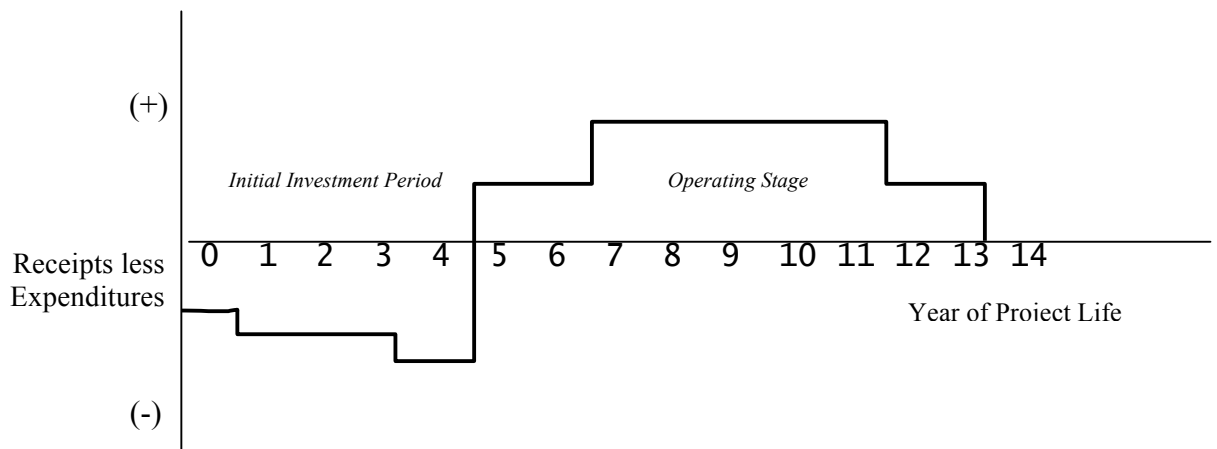
In certain instances the government approaches a project like a private sector investor to determine its financial profitability. This is necessary if private participation in the project is being contemplated. In this case, it is important to determine the profitability of a project and to estimate the value that a private investor would be willing to pay for the opportunity to participate. Ascertaining the financial profitability is also necessary when government policies are designed to encourage small investors or certain groups in society to undertake projects by providing them with grants or loans. Although the government’s decision to provide grants or loans for these activities should be based on whether all small investors undertaking the project yields positive economic returns or not, the government will need to also determine if the projects are financially sustainable.

Another reason for conducting a financial appraisal of public-sector projects is directly related to understanding of the distributional impacts of the project. For example, the difference between the financial price an individual pays for a liter of water (found in the financial cash flow statement) and the gross economic benefit he derives from consuming the water (found in the economic resource flow statement) reflects a net gain to the consumer. Similarly, the difference between the financial price (inclusive of tax) that a project faces and the economic cost of an input required by the project measures the tax gain to the government. Gains and losses of this nature will be difficult to establish on the basis of economic analysis alone.

3.3 Construction of Financial Cash Flows: Concepts and Principles

The financial cash flow of an investment project is a central piece of the financial appraisal. The cash flow statement of a project is a listing of all anticipated sources of cash and uses of cash by the business over the life of the project. It can be illustrated as in Figure 3.1, where the difference between receipts and expenditures is plotted against the sequence of years which make up the project's life. The net cash flow profile (measured by the difference between receipts and expenditures) is usually negative in the beginning of a project's life when the investment is being made. In later years, when revenues from sales of output become larger than expenditures, the net cash flow becomes positive. Some projects, which require significant investments to be made at intervals throughout the life of a project such as the re-tooling of a factory, may also experience negative cash flows occasionally after the initial investment has been made. Other projects may have negative cash flows in their operating stage if they are producing a good or service which experiences wide swings in price or demand. Some other projects will even have negative cash flows in the final years of the project's life as costs are incurred to rehabilitate the project site or to compensate workers for their displacement.

Figure 3.1: Financial Cash Flow Profile of a Project



3.3.1 The Investment Phase

The first step in the construction of a financial cash flow statement is the formulation of an investment plan for the project based on the information developed in the technical, demand, manpower, and financing modules. The investment plan consists of two sections: the first section deals with the expenditure on new acquisitions, and the opportunity cost of existing assets, and the second section deals with the financing aspects of the proposed investment. If there are different scales and/or locations under consideration, corresponding investment plans for each scale and/or location should be formulated. It is important that the investment plan conforms to what is a realistic time schedule given the demand for the project's output, manpower, financial, and supply constraints in the economy, as well as the technical attributes of the project.

The investment plan will contain a listing of all the expenditures to be undertaken up to the point where the facility is ready to begin its normal operations. Each of these expenditures should be identified according to the year in which it is expected to occur. In addition, every expenditure should be broken down into two parts: first, the amount spent on goods and services traded internationally and second, the amount being spent on goods and services traded domestically. These categories of expenditures are in turn divided into the payments received by the suppliers of these goods, payments to the government (such as tariffs, value

added taxes, etc.), subsidies received from the government, and subsidies for the purchase of the investment items. Expenditures on labor for the construction of the project should be identified by year and by skill level for providing a clear understanding of its cost structure and determining if there is likely shortage of skilled workers. These breakdowns are also necessary for estimating the respective shadow price of labour in the economic analysis of the project.

(a) Treatment of Assets

Depreciation expense or capital cost allowances are an accounting device to spread the cost of capital assets over the length of life of these investments so that net income in any given year will reflect all the costs required to produce the output. However, depreciation expense is not a cash outflow and thus should not be included in the financial cash flow profile of the project. The full capital costs of an investment are accounted for in the financial cash flow profile since the amount of the investment expenditures are deducted in the year they occur. If any further capital charge, such as depreciation expense, were deducted from the cash flow profile, it would result in a double counting of investment opportunity cost of existing assets.

If the project under consideration is an ongoing concern or a rehabilitation project where some of the project's old assets are integrated into the proposed facilities, the opportunity cost of these assets should be included in the cash flow statement together with the expenditure on new acquisitions.

It is necessary to distinguish the “opportunity cost” of an asset from the “sunk cost” of an asset. The opportunity cost of using an asset in a specific project is the benefit foregone by not putting the asset to its best alternative use. To measure the opportunity cost of an asset, a monetary value has to be assigned to it in such way that should be equal to what has been sacrificed by using it in the project rather than in its next best use. On the other hand, the value of an asset is treated as a sunk cost if the asset has no alternative use.¹

¹ Sunk cost involves neither current nor future opportunity cost and therefore should have no influence in deciding what will be the most profitable thing to do. It should, however, be noted that while the sunk cost of an asset should not be counted as a cost to a new project in examining its feasibility, any outstanding liabilities due

The opportunity cost of the existing assets is generally included in the first year of the project's cash flow profile because the assets could be sold at that time if the project is not feasible. The financial opportunity cost of an existing asset is the highest financial price that it could be sold for. The highest financial price is typically the higher of the in-use value of the asset and its liquidation value. The in-use value of the asset is what it would sell for if it were to be used as an ongoing concern. The liquidation value is what the asset would sell for if broken into its different components and sold in parts. The costs of installing machine and equipment as well as their liquidation cost are further deducted in order to derive the net liquidation value of the assets. When considering the opportunity cost of any production plant, one should consider the in-use value of the plant if it continues to be operated as it is.

The most appropriate way to determine in-use and liquidation values is through reliable market assessors. When estimating in-use values using assessors, the assessor's and sales agency's fees should be subtracted from the quoted value to obtain the net in-use value. As well, when assessors give a liquidation value for a project's assets, the assessors' and sales agency's fees as well as the expenditures incurred in dismantling the assets should be netted from the quoted price to obtain a net liquidation value.

An approach to preparing an estimate of the in-use value of a set of assets is to consider their net replacement costs. The net replacement cost is the amount of expenditures that would have made today to build a facility that would provide the same amount of services in the future as would the assets that are now being evaluated. To estimate the net replacement value of an asset, two adjustments must be made to the historical purchase cost of assets. The first adjustment is for the change in the nominal prices of new assets or the same type of the asset can perform the same function as the asset being evaluated. This change in price is measured as the ratio of the current price or price index for this asset to the price or price index of the evaluated asset in the year when purchased.

to that asset may become the liability of the new project if the ownership is the same.

The second parameter needed to estimate an asset's net replacement cost is the amount of economic depreciation that the asset has experienced since it was purchased. The economic depreciation rate for an asset reflects the loss in the market value of the asset, which is generally different from the depreciation rate used for tax purposes. The purchase price of an asset adjusted for inflation and net of the cumulative amount of economic depreciation over years since it was purchased represents the opportunity cost of the asset if it is used over its remaining lifetime in a project.²

Suppose that the historical cost of a machine fully installed was A_0 and the machine's cumulated economic depreciation over years expressed as a fraction is d_t , and I_t is the price index for this type of asset today, and I_h is the price index for this type of asset in the period it was initially purchased. Hence net replacement value (in-use value) of the machine in year t can be estimated as follows:

$$(\text{Net replacement value})_t = A_0 * (1 - \text{Proportion of Asset Depreciated } d_t) * (I_t / I_h)$$

The same calculation is carried out for other types of the existing asset. The sum of the above net replacement values for all existing assets needs further adjustments to account for the opportunity cost of land, inventory, and the excess of accounts receivable over accounts payable in year t in order to derive the total amount of the net replacement value. This value will be considered as the opportunity cost of the historical investments or all existing assets for the "without" and "with" the project case.

(b) Treatment of Land

Land has an opportunity cost like every other asset when it is used by a project. Even if the land is donated to the project by the government, it should be included as part of the investment cost at a value that reflects the market value of land in the project area.

Land is a very special asset because it does not depreciate under most situations. However,

² Economic depreciation rates for plants and equipment may be obtained from the plant manufacturer, technical journals, or insurance companies that insure a plant's assets.

due to improvements in infrastructure, the value of land being used by a project may increase much faster than inflation during the life of the project. In such cases it is important not to include the increase in land value that is above inflation as part of the liquidation value of the project. In most cases the increase in the liquidation value of land (particularly in urban areas) has nothing to do with the project under evaluation. Real increases in land value usually come about because of investment being made in public sector infrastructure. It is important not to attribute the increase in the real value of land to any particular project to avoid introducing a bias toward land intensive projects. The only exception to this rule occurs when the project either improves or causes damage to the land. In such cases the amount of the land improvement or deterioration should be added to or subtracted from the real value of the land measured at the beginning of the project to determine the liquidation value of the land at the end of the project.

Alternatively, the opportunity cost of land can be reflected in the cash flow profile of the project by an annual rental charge. This rental charge can be estimated by using the rental rate per dollar value of the land times the real value of the land for each period of the project's life. If the annual rental charge approach is used, then neither the initial cost of the land nor its final market value should enter into the cash flow profile of the project.

(c) Investment Financing

The investment plan also deals with the means and schedule of financing the investment expenditures. The financing may consist of equity, grants, domestic short-term and long-term loans, foreign loans, concessional loans and other forms of foreign aid. They should be identified and the disbursement schedules should be formulated. Which of these financings will be included in the cash flow statement depends on the point of view considered. While appraising the project from the owner's point of view, for example, the loan disbursement is a cash inflow and the repayment of loan and interest payment are a cash outflow as the owner is looking to the net receipts after paying all debts and obligations. The analysis from a banker's point of view, however, is not concerned with the financing but is looking to determine the financial viability of the project to all investors irrespective of debtors or shareholders.

In the case of public sector projects, it is the financial performance of the entire invested capital and not just the equity portion that is relevant for investors. Often both debt and equity financing come from the same source and the loans have been either explicitly or implicitly guaranteed by the government. We will therefore begin our development of the financial cash flows of this project by making no distinction between the return received by the lenders of debt and that received by the equity holders. In this case, the cash made available through borrowing is not considered as a cash inflow, nor are the interest or amortization payments on this debt considered as cash outflows.

The analysis of the financial cash flow from alternative points of view will be discussed later in more detail. Table 3.1 provides an example of an investment phase for a medium-scale mining project.

Table 3.1: Investment Phase for a Mining Project
(Millions of dollars)

Item	Year	0	1	2.....7
A. Investment Expenditures				
<i>(a) Site Preparation, Exploration, and Development</i>				
Materials:				
- Traded (cif)		500.0	500.0	
Tariffs @12%		60.0	60.0	
VAT @10%		56.0	56.0	
- Non-traded		400.0	300.0	
VAT @5%		20.0	15.0	
Labor:				
- Skilled		150.0	100.0	
- Unskilled		200.0	250.0	
<i>(b) Equipment</i>				
Traded (cif)		600.0	2,000.0	
Tariffs @10%		60.0	200.0	
VAT @10%		66.0	220.0	
Total Expenditures		2,112.0	3,701.0	
B. Financing				
<i>Equity</i>		2,012.0	1,201.0	
<i>Domestic Loan (short-term)</i>		100.0	500.0	
<i>Foreign Loan (guaranteed by government)</i>		0	2,000.0	

Total Financing	2,112.0	3,701.0	
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Interest during construction is an item that is often included as an accounting cost in the construction phase. This item is included as a cost to reflect the interest foregone because funds have been tied up in the construction of the project. It is not a measure of interest that has actually been paid, but an accounting device to measure the opportunity cost of the funds employed in the project. If no interest has been paid by the project, then interest during construction is not cash expenditure and should not be included as expenditure in the cash flow statement of the project. On the other hand, if interest payments have been made during the period of construction, then there is a cash outflow when the project is being examined from the viewpoint of the owner.

3.3.2 The Operating Phase

The operating phase of the financial cash flow statement includes all cash receipts generated from the operation of the project and all operating expenditures. Expenditures and receipts should be projected by year of operation. Like investment expenditures, operating expenditures should be broken down into internationally traded and non-traded items; and each expenditure item should be broken down into its components, whenever possible. For example, maintenance expenditures should be broken down into materials and labor. Expenditures on different types of labor (engineers, electricians, managers, etc.) should be identified and recorded separately. Any taxes or subsidies associated with the operating expenditures should also be identified and recorded separately whenever possible. These breakdowns are necessary for the economic analysis of the project and for providing a better understanding of the cost structure of the operating expenditures.

(a) Adjustment for Sales to Find Cash Receipts

A project's viability is not only determined by the sales it generates but also by the timing of the cash receipts from the sales. A cash flow statement records sales transactions only when

the cash from the transaction is received. Typically projects forecast their sales as a single line item which comprises both credit and cash transactions.

A distinction must be made between sales and cash receipts. When a project makes a sale, the good or service may be delivered to the customer but no money transferred from the customer to the project. At this point the project's accountants will record that the project has an asset called accounts receivable equal to the amount of the sale and the proportion of it that is not in cash. In other words, the buyer owes the project for the goods or services that he has purchased and not yet paid for. Until the buyer has paid for what he has received, the transaction will have no impact on the cash flow statement. When the buyer pays for the items that he previously bought from the project, the project's accountants will record a decrease in accounts receivable by the amount that the buyer has paid and an increase in cash receipts. Thus, the cash receipts for any period can be calculated as follows:

$$\begin{array}{rclcl} \text{Cash receipts} & = & \text{Sales} & + & \text{Accounts receivable} & - & \text{Accounts receivable} \\ \text{for period (inflow)} & & \text{for period} & & \text{at beginning of period} & & \text{at end of period} \end{array}$$

Suppose the accounts receivable recorded on the balance sheet at the beginning of the period is equal to \$2,000 and then equal to \$2,600 at the end of the period. Sales for this period as recorded on the income statement are assumed to be \$4,000. Total receipts or cash inflow for this period is calculated as follows:

$$\text{Cash Inflow} = \$4,000 + \$2,000 - \$2,600 = \$3,400$$

Accounts receivable are typically measured as a percentage of sales. It is important to ensure that the accounts receivable selected for the project are consistent with the current performance of industry standards. Also important is to assess the likelihood for bad debts and to make allowances for them. Bad debts occur when a project's customers default on their payments. They simultaneously reduce the amount of cash inflows to the project and reduce the amount of accounts receivable at the end of the period.

Suppose in the previous example bad debts of \$200 had been written off during the period. In this case cash receipts for the period are determined as follows:

$$\begin{aligned}
 \text{Cash receipts} &= \text{Sales} + \text{Accounts receivable} - (\text{Accounts receivable} \\
 \text{for period (inflow)} & \text{ for period} \quad \text{at beginning of period} \quad \text{at end of period} \\
 & + \text{Bad debts written off} \\
 & \quad \text{During the period)
 \end{aligned}$$

$$\text{Cash Inflow} = \$4,000 + \$2,000 - (\$2,600 + \$200) = \$3,200$$

It should be noted that the increase in cash receipts and the decrease in accounts receivable will be augmented by the VAT or other sales taxes associated with the sale of the items. These taxes are collected by the firm on behalf of governments and will be paid to the government later. Such sales taxes will now be included in the cash flow statement of the seller as a part of the cash inflow when these payments are received, but the amount of sales tax will be subtracted from the net cash flow when the taxes are paid to find cash expenditures.

(b) Adjustment for Purchases

Similar to the distinction between sales and receipts, a distinction is necessary between the purchases made by the project and its cash expenditures. The value of the transaction will be recorded in the cash flow statement only when and to the degree that cash is paid. When the project makes a purchase, the good or service may be delivered to the project but perhaps no money is transferred from the project to its vendor. At this point the project's accountants will record that the project has a liability called accounts payable equal to a portion of the amount of the purchase that is not paid in cash. Until the project has paid for what it has received, the transaction will have no impact on the cash flow statement. When the project pays the vendors for the items it has bought from them, the project's accountants will record a decrease in accounts payable by the amount that the project has paid and an increase in cash expenditures. Hence, cash expenditures can be calculated from the value of purchases for the period along with the value of accounts payable both at the beginning and ending of

the period as follows:

$$\begin{array}{rclcl} \text{Cash expenditures} & = & \text{Purchases} & + & \text{Accounts Payable at} & - & \text{Accounts Payable} \\ \text{for period (outflow)} & & \text{for period} & & \text{beginning of period} & & \text{at end of period} \end{array}$$

Assume that total accounts payable at the beginning of a period is equal to \$3,500 and at the end of the period it is \$2,800, with the value of purchases from the income statement being \$3,800. Therefore, total expenditure or cash outflow is calculated as follows:

$$\text{Cash Outflow} = \$3,800 + \$3,500 - \$2,800 = \$4,500$$

Accounts payable are typically measured as a percentage of total purchases or that of a major input. It is important to ensure that the accounts payable on which the cash flow will be based are consistent with the industry standards.

(c) Adjustment for Changes in Cash Balance

Increases or decreases in cash balances can take place even when no changes occur in sales, purchases, accounts receivable, or accounts payable. When cash is set aside for the transaction of the business, a very important reason for the accumulation of cash occurs when the financial institutions that make loans to a project require that a debt service reserve account be set up and funded. The accumulation of cash for this or other purposes represents an outflow in the cash flow statement and must be financed. Similarly, a decrease in cash held for transaction purposes is a source of cash for other uses by the project and thus is a cash inflow. Thus, if the required stock of cash balances to be held to carry out transactions increases in a period, this increase is recorded as a cash outflow. On the other hand, if cash balances decrease, this decrease is a cash inflow. At the end of the project, any cash set aside will ultimately be released back to the project as a cash inflow. The amount of cash to be held for facilitating the transactions of the business is typically a percentage of the project's expenditures, sales, or its pattern of debt service obligations.

(d) Adjustment for Other Working Capital Items

In order to carry out an economic activity, a certain amount of investment has to be made in items that facilitate the conduct of transactions. These items are working capital including cash, accounts receivable, accounts payable, prepaid expenses, and inventories. The first three items have already been dealt with as explained above. Prepaid expenses such as insurance premiums are recorded in the cash flow statement as other expenditures are made.

Changes in inventories are not recorded separately in the cash flow statement. When a project purchases a certain amount of raw materials, inventories of raw materials will increase. These inventories are financed either through a cash outflow and/or an increase in accounts payable. If the inventories have been paid for in cash, then a cash outlay has been recorded in the cash flow statement. If they have been acquired on credit terms, no cash outflow will occur and they will be recorded in purchase as an increase in accounts payable. The situation is similar when dealing with changes in the inventories of the final product. In this case other inputs such as labour and energy are needed to transform raw materials into finished goods. To do this additional cash expenditures will be required. A decrease in final good inventories implies that a sale has occurred. This in turn implies an increase in cash receipts or accounts receivable.

Since the components of working capital are developed independently in different ways, it is necessary to check for the overall consistency of working capital to ensure adequate provision has been made for working capital in order to carry out the business transactions of the project. This can be done by comparing the amount of working capital estimated as a proportion of total assets of the project to the industry average or with similar businesses that are operating successfully.

(e) Income tax Liability

Income taxes paid by the project should be included as an outflow in the cash flow statement. The income tax liability is estimated on the basis of the project's income

statement following the accounting and tax rules of the country concerned. Year by year estimates of the cost of goods sold, interest expense, tax depreciation expenses, and overheads are all subtracted from the project's revenues to estimate the project's earning before taxes. While estimating the income tax liability, provisions for loss carry backward and forward if applicable should be taken into account.

(f) Value Added Tax Liability

Most countries levy value added taxes on the goods and services sold domestically, but zero rate sales made to customers living outside of the country. For a taxable firm the value of sales will include the value added taxes collected by the project on behalf of the government. The cost of inputs that are taxed will include the value added taxes paid on these purchases. The payment made to the government, if the firm is taxable, is the difference between the value added taxes collected on the sales and the value added taxes paid on the purchase of inputs. These payments of VAT to the government are reported in the cash flow statement as an outflow. The net effect of this tax treatment is to largely eliminate the VAT from being financial burden on the project.

When a project produces an output that is exempt from VAT it will not be charging VAT when it sells its output. On the other hand, in most circumstances it will continue to pay VAT on its purchases of inputs. In this case there will not be an additional line item reporting the VAT payment to the government. The net effect of the VAT is to increase the cost of the inputs and hence the financial cash outflow of the project.

The third possible situation occurs when the output of the project is expected with a rate of zero imposed on the export sales. In this case no tax is included in the sales revenues or cash inflows. The VAT will be levied and included on the inputs purchased by the project. The difference between the taxes collected on sales of zero and the taxes paid as part of the input purchases now becomes a negative tax payment or a refund of taxes paid. This should be reported as a negative cost or a cash inflow to the project.

3.3.3 Cessation of Project Operations

When a new project acquires an asset, the entire expenditure on the asset is accounted for in the cash flow statement at the time that the expenditure actually occurs. It is quite possible, however, that the life of the project will not coincide with the life of all its assets, or that the span of the analysis will not extend as far in the future as the project may be expected to operate (e.g., railway projects). Then the residual value of the asset should be included in the cash flow statement as an inflow in the year following the cessation of operations.

When determining the residual value of the assets at the end of the project, it is preferable to break down all the assets into different categories: land, building, equipment, vehicles, etc. The residual value is taken as the in-use value unless it is clear the facility will be shut down at the end of the project period. If it is to be shut down, then the liquidation value should be used as the residual value. The in-use value of the plant is the value of the plant under the assumption that it will continue to operate as an on-going concern. The liquidation value is the value of the assets if all components of the project are sold separately and perhaps even the plant is taken apart and sold.

While dealing with the in-use and liquidation in the future, general guidelines are to use the cumulative economic depreciation over years. The depreciation rates can be obtained from plant manufacturers, technical journals or the depreciation rates used by insurance companies.

Land is a special asset that generally does not depreciate. The residual value of land recorded in the cash flow statement should be equal to the real market value of the land recorded at the beginning of the project, unless the project results in some improvement or deterioration to the land. For example, if a project involves an investment to improve the property such as drainage of a swamp, the residual value of the project should include the increase in land value resulted directly from an investment made by the project. The opposite is the case if the project damages the land and its value. The residual value of the land must be reduced by the amount of damage caused by the project. Notwithstanding, in many cases expectations

may indicate that land values are likely to rise faster than inflation but the increase is totally unrelated to the project.³

3.3.4 Format for the Pro-Forma Cash Flow Statement

While there is no specific format for presentation of the pro-forma cash flow statement for an investment project, it is important that the data should be set out in sufficient details so that the adjustments required by the economic and distributive appraisal can be easily applied to the financial cash flows. Entries for receipts and payments must be classified as outlined in the above discussion of investment and operating phases for the project. Receipts must be identified according to whether they arise from sales of tradable or non-tradable goods with all taxes. Payments should also be presented in a similar fashion with all taxes, tariffs, and subsidies itemized separately. Labor costs must be identified according to the type of labor used.

To illustrate the construction of the financial cash flow statement, we continue with the example of the mine. The investment phase of the project is outlined in Table 3.1. Now, we assume that mining project has an operating life of five years, and the machinery and equipment will be liquidated as scrap at the closure of mine. This is carried out in the year following the mine closure at which time the scrap is expected to yield \$1 billion. The land is assumed to have zero value after being mined. Table 3.2 contains the basic operating information required to develop the pro-forma cash flow statements for this project. For example, accounts receivable and accounts payable are assumed at 20 percent of annual sales and purchases inclusive of VAT, respectively. Desired cash balances are assumed to be equal to 10 percent of purchases of inputs. As the output of the mine is assumed to be exported the export sales will be zero rated for VAT taxation.

³ Expected increases in land values are generally speculative which implies that building such increases in the residual value of land may not occur. Moreover, the purpose of the analysis is to appraise the project and determine its impact on its sponsors. Large increases in land value may be sufficiently large, leading to the implementation of the project and a misallocation of resources. Thus, the residual value of land should be generally the same as its real price at the start of the project.

A 10 percent royalty is charged on the value of export sales. This is paid directly to the government. No income tax is levied on this mining activity.

Table 3-2: Operating Information for the Case of a Mining Project
(Millions of dollars)

Item	Year	0	1	2	3	4	5	6	7
Sales									
- Traded				2,000.0	3,000.0	3,500.0	3,000.0	2,000.0	
- VAT @ 0%				0	0	0	0	0	
Purchases of Inputs									
- Traded (cif)				600.0	750.0	800.0	700.0	600.0	
Tariffs @10%				60.0	75.0	80.0	70.0	60.0	
VAT @10%				66.0	82.5	88.0	77.0	66.0	
- Non-traded				200.0	250.0	320.0	200.0	200.0	
VAT @5%				10.0	12.5	16.0	10.0	10.0	
Operating Labor									
- Skilled				100.0	150.0	200.0	150.0	125.0	
- Unskilled				50.0	70.0	90.0	80.0	60	
Working Capital (end of period values)									
- Account Receivables		0	400.0	600.0	700.0	600.0	400.0	400.0	0
- Account Payables		0	187.2	234.0	260.8	211.4	187.2	187.2	0
- Cash held as working capital		0	93.6	104.5	130.4	105.7	93.6	93.6	0

With the data presented in Tables 3.1, and 3.2, the pro-forma cash flow statement can be constructed in detail broken down by commodity and labor type as Table 3.3. This pro-forma cash flow statement provides the basis for the financial and economic analysis of the project which will follow. It is the net cash flow from this statement that gives us the project profile shown in Figure 3.1.

It should be noted that no VAT is collected on the sales on behalf of the tax authority while VAT paid on purchases can be claimed back as input tax credits under most consumption type VAT system. Thus, a row of VAT input tax credit in Table 3.3 is created in order to derive the impact of the net VAT payments or refund of VAT paid on inputs on the net cash flow for the project.

**Table 3.3: Pro-Forma Financial Cash Flow Statement for an Investment in a Mine
(Millions of dollars)**

Item	Year	0	1	2	3	4	5	6	7
A. Receipts:									
Foreign Sales (traded goods)				2,000.0	3,000.0	3,500.0	3,000.0	2,000.0	0
VAT @ 0%				0	0	0	0	0	
Change in Account Receivables				-400.0	-200.0	-100.0	+100.0	+200.0	+400.0
Liquidation Value (scrapped assets)									1,000.0
Cash Inflow				1,600.0	2,800.0	3,400.0	3,100.0	2,200.0	1,400.0
B. Expenditures:									
a) Site Preparation, Exploration and Development:									
Materials:									
- Traded Goods (cif)	500.0	500.0							
Tariffs @12%	60.0	60.0							
VAT @10%	56.0	56.0							
- Non-traded Goods	400.0	300.0							
VAT @5%	20.0	15.0							
Equipment:									
- Traded (cif)	600.0	2,000.0							
Tariffs @10%	60.0	200.0							
VAT @10%	66.0	220.0							
b) Input Purchases									
- Traded Goods (cif)				600.0	750.0	800.0	700.0	600.0	
Tariffs @10%				60.0	75.0	80.0	70.0	60.0	
VAT @10%				66.0	82.5	88.0	77.0	66.0	
Change in Accounts Payable				-145.2	-36.3	-12.1	24.2	24.2	145.2
- Non-traded Goods				200.0	250.0	320.0	200.0	200.0	
VAT @5%				10.0	12.5	16.0	10.0	10.0	
Change in Accounts Payable				-42.0	-10.5	-14.7	25.2	0	42.0
c) Construction Labor:									
- Skilled	150.0	100.0							
- Unskilled	200.0	250.0							
d) Operating Labor:									
- Skilled				100.0	150.0	200.0	150.0	125.0	
- Unskilled				50.0	70.0	90.0	80.0	60.0	
e) Change in Cash Held as Working Capital				93.6	23.4	13.4	-24.7	-12.1	-93.6
Cash Outflow	2,112.0	3,701.0		992.4	1,366.6	1,580.62	1,311.7	1,133.1	93.6
C. Tax Payments									
(a) VAT (Payment, (Refund))	-142.0	-291.0		-76.0	-95.0	-104.0	-87.0	-76.0	0
(b) Royalty	0	0		200.0	300.0	350.0	300.0	200.0	0
D. Net Cash Flow	-1,970.0	-3,410.0		483.0	1,228.4	1,573.4	1,575.3	942.9	1,306.4

3.4 Use of Consistent Prices in the Cash Flow Forecast

When conducting a financial appraisal of a project, it is necessary to make a projection of prices for the inputs and outputs over its life. These prices are influenced by movements in

the real price of the good in question and the effect of inflation. The factors affecting the real price and inflation are quite different. Real prices are determined by changes in the market demand and/or supply for the specific items while inflation is usually determined by the growth of the country's money supply relative to its production of goods and services. Forecasts of inflation are generally beyond the capability or responsibility of the project analyst. The rate of inflation is basically a risk variable, and the analysis of a project should be subjected to a range of possible inflation rates. The critical issue for the analyst is to construct a projection of nominal prices that are consistent with assumed pattern of inflation rates through time and the projection of changes in real prices.

The projection of the future path of real prices is of particular importance if the price of one or more input or output is significantly above or below its normal level or trend. To understand the impact of real price changes and inflation on the financial viability of a project and how they are incorporated in the analysis, we first consider the definition or derivation of various price variables employed in the analysis.

3.4.1 Definition of Prices and Price Indices

(a) Nominal Prices

The nominal prices of goods and services are those found in the marketplace, and are often referred to as current prices. Historical data for nominal prices are relatively easy to obtain, but forecasting nominal prices in a consistent manner is a notoriously difficult task. The nominal price of an item is the outcome of two sets of economic forces: macroeconomic forces which determine the general price level or inflation, and the forces of demand and supply for the item which causes its price to move relative to other goods and services in the marketplace. In order to construct a cash flow forecasts in nominal prices, we must take into consideration the movement of both real prices and the general price level.

(b) Price Level and Index

The price level for an economy (P_L^t) is calculated as a weighted average of a selected set of nominal prices:

$$P_1^t, P_2^t, P_3^t, \dots, P_n^t$$

The price level P_L^t can be calculated for any period (t) as follows:

$$P_L^t = \sum_{i=1}^n P_i^t W_i \tag{3.1}$$

where: i denotes the individual good or service included in the market basket;

P_i^t denotes the price of the good or service at a point in time;

W_i denotes the weight given to the price of a particular good or service (i); and $\sum W_i = 1$.

The weights used for calculating a price level are defined as of a certain date. This date is referred to as the base period for the calculation of the price level. The weights established at that time will rarely change because we want to compare the level of prices of a given basket of goods between various points in time. Hence, it is only the nominal prices which change through time in equation (3.1), while the weights (W_1, W_2, \dots, W_n) are fixed.

Instead of calculating the price level for the entire economy, a price level may be created for a certain subset of prices such as construction materials or consumer goods. It is generally useful to express the price level of a basket of goods and services at different points in time as a price index (P_I^t). The price index simply normalizes the price level so that in the base period the index is equal to one. If we wish to calculate a price index that compares the price levels in two distinct periods, we can write the equation as follows:

$$P_I^t = P_L^t / P_L^B \tag{3.2}$$

where P_t^t denotes the price level in period (t), and P_L^B denotes the price level for the base period (B). For example, the consumer price index is a weighted average of the prices for a selected market basket of consumer goods. The investment price index is created as a weighted set of goods and services that are of an investment nature. The change in the price index for a broad set of goods and services is used to measure the rate of inflation in the economy.⁴

Suppose there are three commodities in a basket of consumer goods and their prices in Year 1 are \$30, \$100, and \$50 as shown in Example 1. The corresponding weights of these goods are 0.2, 0.5, and 0.3. The price level in Year 1 is \$71 using equation (3.1). If the prices of these three goods in Year 2 become \$40, \$110, and \$40, respectively, the weighted average of the price level will be \$75. Similarly, the price level in Year 3 as shown in the example is \$73.

Example 1: Nominal Prices and Changes in Price			
<i>Assume Year 1 is Base Year</i>			
Goods	1	2	3
Weights	0.2	0.5	0.3
Nominal Prices Year 1:	$P_1^1 = 30$	$P_2^1 = 100$	$P_3^1 = 50$
	$P_L^1 = 0.2(30) + 0.5(100) + 0.3(50) = 71$		
	$P_L^B = 71$		
	Price Index $P_1^1 = 1.00$		
Nominal Prices Year 2:	$P_1^2 = 40$	$P_2^2 = 110$	$P_3^2 = 40$
	$P_L^2 = 0.2(40) + 0.5(110) + 0.3(40) = 75$		
	Price Index $P_1^2 = 1.056$		
Nominal Prices Year 3:	$P_1^3 = 35$	$P_2^3 = 108$	$P_3^3 = 60$
	$P_L^3 = 0.2(35) + 0.5(108) + 0.3(60) = 79$		
	Price Index $P_1^3 = 1.113$		
<ul style="list-style-type: none"> • Inflation Rate: Changes in General Price Level (Measured in terms of a price index) <ul style="list-style-type: none"> $g P_1^2 = [(P_1^2 - P_1^1)/(P_1^1)] * 100 = [(1.056 - 1.00)/(1.00)] * 100 = 5.63\%$ $g P_1^3 = [(P_1^3 - P_1^2)/(P_1^2)] * 100 = [(1.113 - 1.056)/(1.056)] * 100 = 5.33\%$ 			

⁴ In some countries the consumer price index is the best instrument for the measurement of inflation, for others it is the implicit GDP deflator.

Using the price level in Year 1 as the base period, we can calculate the price indices based on equation (3.2) as 1.00, 1.056, and 1.113 for Year 1, Year 2, and Year 3, respectively.

(c) Changes in General Price Level (Inflation)

Inflation is measured by the change in the price level divided by the price level at the beginning of the period. The price level at the beginning of the period becomes a reference for determining the rate of inflation throughout that particular period. Hence, inflation for any particular period can be expressed as in equation (3.3).

$$gP_1^e = [(P_1^t - P_1^{t-1}) / P_1^{t-1}] \times 100 \quad (3.3)$$

Inflation is much more difficult to forecast than the changes in real prices, because inflation is primarily determined by the supply of money relative to the availability of goods and services in an economy to purchase. The supply of money, in turn, is often determined by the size of the public sector deficit and how it is financed. If governments finance their deficit by borrowing heavily from the Central Bank, inflation is inevitably the end result.

In the evaluation of an investment, we need not attempt to make an accurate forecast of the rate of inflation. It is essential, however, to make all the other assumptions concerning the financing and operation of the project consistent with the assumed pattern of future inflation. In most countries, the rate of inflation is a risk variable which we must try to accommodate through the financial design of the project. For example, even though the historical rates of inflation in the economy may be only 5 or 6%, we may want to see if the project can survive if the rate of inflation is much higher and much lower. If the analysis demonstrates that it will be severely weakened, then we may want to ask whether the project can be redesigned so as to better withstand such unanticipated rates of inflation.

(d) Real Prices

Real prices (P_{iR}^t) are an important subset of relative prices where the nominal price of an item is divided by the index of the price level at the same point in time. They express prices

of the goods and services relative to the general price level. This is shown by equation (3.4).

$$p_{iR}^t = p_i^t / P_I^t \quad (3.4)$$

where P_I^t denotes the nominal price of good or service at time (t), and P_I^t denotes the price level index at time period (t).

Dividing by a price level index removes the inflationary component (change in the general price level) from the nominal price of the item. This allows us to identify the impact of the forces of demand and supply on the price of the good relative to other goods and services in the economy.

Example 2 illustrates how real prices are calculated using equation (3.4). For instance, the real price of good 1 in Year 2 is \$37.87, which is obtained from dividing the nominal price \$40 by the price index 1.056.

Example 2: Real Prices and Changes in Real Price			
Goods Weights	1 0.2	2 0.5	3 0.3
Nominal Prices Year 1:	$P_1^1 = 30$ Price Index $P_1^1 = 1.00$	$P_2^1 = 100$	$P_3^1 = 50$
Real Prices Year 1:	$P_{1R}^1 = 30/1$ = 30	$P_{2R}^1 = 100/1$ = 100	$P_{3R}^1 = 50/1$ = 50
Nominal Prices Year 2:	$P_1^2 = 40$ Price Index $P_1^2 = 1.056$	$P_2^2 = 110$	$P_3^2 = 40$
Real Prices Year 2:	$P_{1R}^2 = 40/1.056$ 40/1.056 = 37.87	$P_{2R}^2 = 110/1.056$ = 104.16	$P_{3R}^2 =$ = 37.87
Nominal Prices Year 3:	$P_1^3 = 35$ Price Index $P_1^3 = 1.113$	$P_2^3 = 108$	$P_3^3 = 60$
Nominal Prices Year 3:	$P_{1R}^3 = 35/1.113$ 60/1.113 = 31.45	$P_{2R}^3 = 108/1.113$ = 97.04	$P_{3R}^3 =$ = 53.91
• Changes in Real Prices Year 2:			
Change in $P_{iR}^2 = [(P_{iR}^2 - P_{iR}^1)/(P_{iR}^1)] =$			
	$(37.87 - 30)/30$ = 0.2623	$(104.16 - 100)/100$ = 0.0416	$(37.87 - 50)/50$ = -0.2426
• Changes in Real Prices Year 3:			
Change in $P_{iR}^3 = [(P_{iR}^3 - P_{iR}^2)/(P_{iR}^2)] =$			
	$(31.45 - 37.87)/37.87$ = -0.1695	$(97.04 - 104.16)/104.16$ = -0.0683	$(53.91 - 37.87)/37.87$ = 0.4235

(e) *Changes in Real Prices*

The change in the real price of a good or service can be expressed as:

$$\Delta p_{iR}^t = \frac{p_{iR}^t - p_{iR}^{t-1}}{p_{iR}^{t-1}} \quad (3.5)$$

where p_{iR}^t denotes the real price of good (i) as of a specific period.

Using Example 2 and equation (3.5), we can compute that the change in real price of good 1 in Year 3 is -16.95%.

For each of the inputs and outputs a set of projections must be prepared in the path of its real price over the life of the project. For items where rapid technological change is taking place, such as computers or telecommunication equipments, we would expect that the real price of those goods would fall.

There is one important input, however, whose relative price is almost certain to rise if there is economic development in the country. This is the real wage rate. If economic development takes place, the value of labor relative to other goods and services will have to rise. Hence, in the forecasting of real prices for a project we should consider the potential for real wages to rise and build this into the cost of inputs for a project over its life.

(f) Inflation Adjusted Values

Inflation adjusted values for prices of inputs and outputs are the result of our best forecast of how real prices for particular goods and services are going to move in the future, and this forecast is then adjusted by an assumed path of the general price level over future periods. In other words, we are producing a set of nominal prices which are built up from their basic components of a real price and a price level. These inflation adjusted values are generated in a consistent fashion. A common mistake of project evaluators is to assume that many of the prices of inputs and outputs for a project are rising relative to the rate of inflation. This is highly unlikely. The price level itself is a weighted average of individual goods and services prices. Hence, in the forecast of the real price of the goods and services used or produced by our project, we would expect that approximately as many real prices will be falling as are rising.

To forecast the movement of the real price of a good or service, we need to consider such items as the anticipated change in the demand for the item over time, the likely supply response, and the forces which are going to affect its cost of production. This analysis is very different from that which goes into the forecast of the general price level. This forecast is not so much a prediction, but a set of consistent assumptions. It is the inflation-adjusted values

which we use in the estimation of the nominal cash flows of a project. They can be estimated using equation (3.6):

$$\hat{P}_i^{t+1} = P_i^t (1 + gP_{iR}^{t+1})(1 + gP_I^{t+1}) \quad (3.6)$$

Where \hat{P}_i^{t+1} denotes the estimated nominal price of good (i) in year $t+1$;

P_i^t denotes the nominal price of good (i) in year t ;

gP_{iR}^{t+1} denotes the estimated growth in real price of good (i) between year t and $t+1$;

and

gP_I^{t+1} denotes the assumed growth in price level index from year t to year $t+1$.

(g) *Constant Prices*

It should be noted that real prices are sometimes referred to constant prices, which, as the name implies, do not change over time. They are simply a set of nominal price observations as of a point in time that is used for each of the subsequent periods in a project appraisal. While nominal prices are affected by changes in real prices as well as changes in the price level, constant prices reflect neither of these economic forces. If constant prices are used throughout the life of the project, then we are ignoring both the changes in real prices, which may have a profound impact on the overall financial position of the project, and the impact which inflation can have on the performance of an investment. The use of constant prices simplifies the construction of a cash flow profile of a project, but it also eliminates from the analysis a large part of the financial and economic information that can affect the future performance of the project.

Two specific prices are discussed below due to the important role they play in the financial analysis of projects. These are the interest rate and the price of foreign exchange.

3.4.2 Nominal Interest rate

One of most important features for integrating expectations about the future rate of inflation (gP^e) into the evaluation of a project is to ensure that such expectations are consistent with the projections of the nominal rate of interest. Lenders increase the nominal interest rate on the loans they give to compensate for the anticipated loss in the real value of the loan caused by inflation. As the inflation rate increases, the nominal interest rate will be increased to ensure that the present value of the interest and principal payments will not fall below the initial value of the loan.

The nominal interest rate, as determined by the financial markets, is made up of three major components: the real interest rate (r) which reflects the real time value of money that lenders require in order to be willing to forego consumption or other investment opportunities, a risk factor (R) which measures the compensation lenders demand to cover the possibility of the borrower defaulting on the loan, and a factor $(1+r+R)gP^e$ which represents the compensation for the expected loss in purchasing power attributable to inflation. The expected real interest rate will be relatively constant over time because it is primarily determined by the productivity of investment and the desire of consumption and saving in the economy. The risk premium is typically associated with the sector and investor and is known. Inflation reduces the future value of both the loan repayments and real interest rate payments. Combining these factors, the nominal (market) rate of interest (i) can be expressed as:

$$i = r + R + (1 + r + R) gP^e \quad (3.7)$$

To explain this concept more fully, let us consider the following financial scenarios. When both risk and inflation are zero, a lender would want to recover at least the real time value of money. If the real interest rate r is 5 percent, then the lender would charge at least a 5 percent nominal interest rate. If the lender anticipates that the future rate of inflation will be 10 percent, then he would want to increase the nominal interest rate charged to the borrower in order to compensate for the loss in purchasing power of the future loan and interest rate

payments. Maintaining the assumption that there is no risk to this loan, we can apply the equation (3.7) to determine what nominal interest rate he would need to charge to remain as well off as when there was no inflation:

$$\begin{aligned}i &= r + R + (1 + r + R) gP^e \\ &= (0.05) + (0) + (1 + 0.05 + 0) \cdot 0.1 \\ &= 15.5\%\end{aligned}$$

Thus, the lender will need to charge a nominal interest rate of at least 15.5 percent to achieve the same level of return as in the zero inflation scenarios.

If now suppose the risk premium (R) is 3 percent. In this case the nominal interest rate that is consistent with a 5 percent expected real interest rate and an expected rate of inflation of 10 percent is: $i = (0.05) + (0.03) + (1 + 0.05 + 0.03) \cdot 0.1 = 0.188$.

If the rate of inflation is expected to change through time and if refinancing of the project's debt is required, then the nominal interest rate paid must be adjusted to be consistent with this new expected rate of inflation. This should have little or no direct effect on the overall economic viability of the project as measured by its NPV; however, it may impose very severe constraints on the liquidity position of the project because of its impact on interest and principal payments if not properly planned for.

3.4.3 Expected Nominal Exchange Rate

A key financial variable in any project using or producing tradable goods is the market rate of foreign exchange (E^M) between the domestic and the foreign currency. This market exchange rate is expressed as the number of units of domestic currency (#D) required to purchase one unit of foreign exchange (F). The market exchange rate refers to the current nominal price of foreign exchange. It needs to be projected over the life of the project. The market rate between the domestic and the foreign currency can be expressed at any point in time (t) as:

$$E_t^M = (\#D/F)_t \quad (3.8)$$

The real exchange rate, $E_{t_n}^R$, can be defined as follows:

$$E_{t_n}^R = \frac{\#D / I_{t_n}^D}{F / I_{t_n}^F} = \frac{\#D}{F} \frac{I_{t_n}^F}{I_{t_n}^D}$$

or, $E_{t_n}^R = E_{t_n}^M \frac{I_{t_n}^F}{I_{t_n}^D}$ (3.9)

where $E_{t_n}^M$ denotes the market rate of exchange in year t_n and $I_{t_n}^D$ and $I_{t_n}^F$ represent the price indices in year t_n for the domestic currency country and the foreign currency country, respectively.

The difference between the real and the nominal exchange rate at a given point in time, t_n , lies in the relative movement of the price index of foreign to the domestic country as measured from an arbitrary chosen point in time, t_b (base year) to the time of interest, t_n . The cumulative inflation for the domestic country over a period of time is given by the domestic price index $I_{t_n}^D$. The domestic price index at any point in time t_n can be expressed as the price index in any initial year t_0 , $I_{t_0}^D$, times the cumulative change in the price level from time t_0 to t_n . This is given as follows:

$$I_{t_n}^D = I_{t_0}^D \prod_{i=1}^n (1 + gp_{t_0+i}^{de}) \quad (3.10)$$

where gp_i^{de} is the rate of inflation in the domestic economy.

Similarly, the foreign price index at any point in time t_n , using the same reference year t_0 as the base year, can be expressed as the price index in any initial year t_0 , $I_{t_0}^F$, times the cumulative change in the price level from time t_0 to t_n . This is given as follows:

$$I_{t_n}^F = I_{t_0}^F \prod_{i=1}^n (1 + gp_{t_0+i}^{fe}) \quad (3.11)$$

where gp_i^{fe} is the rate of inflation in the foreign economy.

By substituting (3.10) and (3.11) into equation (3.9), we can calculate the nominal exchange rate in a future time period n as:

$$E_{t_n}^M = E_{t_n}^R \times \frac{I_{t_0}^D \prod_{i=1}^n (1 + gp_{t_0+i}^{de})}{I_{t_0}^F \prod_{i=1}^n (1 + gp_{t_0+i}^{fe})} \quad (3.12)$$

For convenience when conducting a financial appraisal of a project, we can select the first year of the project, t_0 , as the arbitrary reference point or base year for the calculation of the relative price indices. Using t_0 as the base year, then both the values for $I_{t_0}^D$ and $I_{t_0}^F$ will be equal to one in that year. Hence, there will be no difference between the real and nominal exchange rates in that base period.

In the case where the initial price levels for the domestic and the foreign country are set equal to 1 in time period t_0 , then the expression (3.12) for the market exchange rate can be simplified to,

$$E_{t_n}^M = E_{t_n}^R \times \frac{\prod_{i=1}^n (1 + gp_{t_0+i}^{de})}{\prod_{i=1}^n (1 + gp_{t_0+i}^{fe})} \quad (3.13)$$

The real exchange rate will move through time because of shifts in the country's demand and supply for foreign exchange. It is very difficult to predict the movement of the real exchange rate unless it is being artificially maintained at a given level through tariffs or quantitative restrictions on either the supply or demand of foreign exchange. In some situations when the real exchange rate is believed to be currently either above or below its longer term equilibrium level then a trend in the real exchange rate for a limited number of years may be projected. The ratio of the two price indices is known as the relative price index. If through time the domestic economy faces a rate of inflation different than that of foreign trading partner, the relative price index will vary over time. If the real exchange rate remains constant in the presence of inflation, then the change in the relative price index must result in a corresponding change in the market exchange rate.

Since the future real exchange rate is only likely to be known with some uncertainty, and the market exchange rate might not adjust instantaneously to changes in the rate of inflation, it is more realistic to allow some flexibility in the estimation of the market exchange rate. This is carried out by assuming a range for the distribution of possible real exchange rates around an expected mean real exchange rate. To incorporate this aspect we write the above equation as follows:

$$E_{t_n}^M = E^R * (1 + k) \frac{\left(\prod_{i=1}^n \left(1 + gp_{t_0+i}^{de} \right) \right)}{\left(\prod_{i=1}^n \left(1 + gp_{t_0+i}^{fe} \right) \right)} \quad (3.14)$$

where k is a random variable with a mean value of zero.

3.4.4 Incorporating Inflation in the Financial Analysis

Much of the published literature on project evaluation recommends the exclusion of inflation from the appraisal process.⁵ These methods only account for projected changes in relative

⁵ Squire, L. and van der Tak, H.G., *Economic Analysis of Projects*, Baltimore: The Johns Hopkins University Press, (1975), p. 38.

prices of inputs and outputs over the life of the investment.⁶ However, experience with projects suffering from financial liquidity and solvency problems has demonstrated that inflation can be a critical factor in the success or failure of projects. Correctly designing a project to accommodate both changes in relative prices and changes in the rate of inflation may be crucial for its ultimate survival.

Improper accounting for the impacts of inflation when conducting the financial analysis could have detrimental effects not only on the financial sustainability of a project but also on its economic viability. Assumptions regarding inflation will have a direct impact on the financial analysis of the project and may require adjustments in the operating or investment policies. Since an inadequate treatment of inflation may adversely affect the financial sustainability of the project, ultimately the economic viability of the project may be compromised if inflation is not properly accounted for.

It is important to realize that the ultimate analysis of the financial cash flows should be carried out on a statement prepared in real domestic currency. It is difficult to correctly analyze nominal net cash flow statements as one will be attempting to understand figures that reflect two changes: changes in the real price and changes in inflation. Moreover, when preparing the cash flow statement, certain variables such as tax liabilities, cash requirements, interest, and debt repayments need to be estimated in the current prices of the years they incur. The correct treatment of inflation requires that preparatory tables be made using nominal prices, and then deflate the nominal cash flow statements to obtain the cash flow statements in real prices. By constructing the financial analysis in this manner, we ensure that, all the effects of change in real prices as well as inflation are consistently reflected in the projected variables.

⁶ All of the following authors recommend that expectations of inflation be ignored in the evaluation of projects: Little, I.M.D. and Mirrlees, J.A., *Project Appraisal and Planning for Development Countries*, London: Heineman Educational Books Ltd., (1974); United Nations Industrial Development Organization, *Guidelines for Project Evaluation*, New York: United Nations, (1972), and Curry, S. and Weiss, J., *Project Analysis in Developing Countries*, New York: St. Martin's Press, Inc., (1993). A more satisfactory treatment of this issue is provided by Roemer, M. and Stern, J.J., *The Appraisal of Development Projects, A Practical Guide to Project Analysis with Case Studies and Solutions*, New York: Praeger Publishers, (1975), pp. 73-74.

Outlined below are steps required for incorporating inflation into the financial cash flow of a project in a consistent manner:

1. Estimate the future changes in the real prices for each input and output variable. This will involve the examination of the present and future demand and supply forces that are expected to prevail in the market for the item. For example, an examination of real prices of many electronic goods and services will indicate that they have been dropping a few percentage points a year over the past decade. Real wages, on the other hand, tend to increase over time as the economy grows.
2. Develop a set of assumptions concerning the expected annual changes in price level over the life of the project, and calculate expected inflation rate.
3. Determine what the nominal rate of interest will likely be over the life of the project given the expected changes in the price level estimated above.
4. Combine the expected change in real prices for each input and output with the expected change in the rate of inflation to get the expected change in the nominal price of the item.
5. Multiply the nominal prices for each item by the projections of quantities of inputs and outputs through time to express these variables in the current year's prices of the period in which they are expected to occur.
6. Begin the construction of a cash flow statement using the nominal values for the inputs and outputs.
7. Determine financing requirements along with the interest payments and principal repayments and include these items in the income tax statement and also in the cash flow statement.
8. Construct income tax statement for each year of the project's life to determine income tax liabilities with all variables expressed in their nominal values. Depreciation expenses, cost of goods sold, and interest expenses and income tax liabilities are estimated according to taxation laws of the country in question. The estimated income tax liabilities are included in the cash flow statement.
9. Estimate accounts receivable, accounts payable, and any changes in the stock of cash that are reflected in the cash flow statement. This completes the construction of the

- projected variables in terms of their current values.
10. Construct the nominal cash flow statement from the total investment point of view by assembling all projected annual cash receipts, annual cash expenditures in current prices and changes in cash balance over the life of the project.
 11. Add loans received from bankers as cash inflow and subtract interest payments as cash outflow to become the cash flow statement in current prices from the owner's point of view. Deflate all items in the owner's cash flow statement by the price index to arrive at real values for the cash flow statement. Note that loans, interest payments, and loan payments are also deflated and included in the cash flow statement in real prices.
 12. Discount the net financial cash flow to the owners of the enterprise. The appropriate discount rate will be the real private opportunity cost of equity financing if the owner of the enterprise is a private owner. However, in case of public sector enterprise, the appropriate discount rate will be the target financial rate of return (net of inflation) set by government.
 13. Calculate the net financial cash flows accruing to any other points of view that are relevant for the project.

The development of pro-forma financial cash flow statements in this way ensures that the impact of inflation on the financial performance of the project is correctly accounted for. At the same time, the final financial analysis is completed with the variables expressed in terms of the price level of a given year. In this way, the movement of such variables as receipts, labor costs and material costs can be compared over time without being distorted by changes in the general price level.

When the financial analysis is carried out in terms of real prices, it is essential that the private opportunity costs of capital or the target financial rates of return used as discount rates be expressed net of any compensation for the expected rate of inflation. In other words, these discount rates must be real, not nominal, variables. If a nominal private cost of capital or target rate of return is used, the result will be a double correction for the expected changes

in the general price level. Such practices will greatly distort the conclusions of the analysis concerning the financial viability of the project.

It should be noted that the real financial prices for the input and output variables developed above are used as the base on which to estimate the economic values for the benefits and costs of the project. Once these economic costs and benefits are estimated, an economic resource flow statement can be constructed. The structure of the statement should be similar to that of the financial cash flow statement. The difference between the two statements is analyzed to determine the impacts of the project on various stakeholders.

3.5 Analyses of Investment Decisions from Alternative Viewpoints

Most investment projects can be evaluated from the prospective of different actors or institutions which are directly affected by the project. These actors or institutions in a commercial project are in fact stakeholders including the owner or equity holder, the supplier of raw materials, the workers employed in the project, the bank or financing institution, the government's budget office, or the country as a whole. In the case of projects involving some government intervention in the form of grants, subsidies, loans, or a joint-venture, the stakeholders may be different from the above list depending upon the specific types of the project. Nevertheless, it is necessary to conduct the analyses from the viewpoints of the different important stakeholders to ensure the project's sustainability and success. This is to minimize the situation in which one powerful stakeholder who is adversely affected by the project may be able to derail the entire project.

The most commonly-undertaken financial analyses for the commercial and government-related projects are from the viewpoints of owner, banker, government, and country. These points of view are discussed below focusing on differences in the variables included in the analyses from the different perspectives.

3.5.1 The Banker's Point of View

A banker's first and foremost interest is to determine the overall strength of the project whether potential loans the project may require are secured. A banker sees a project as an activity that generates tangible financial benefits and absorbs tangible financial resources. It disregards any distinctions in the sources of finance but asks the question whether the financial receipts generated from the operations of the project are sufficient to cover the investment and operating expenditures and to provide a sufficient return or not.

Known also as the total investment point of view, the banker takes into account all financial benefits and costs of the project so that he will be able to determine the financial feasibility of the project, the need for loans, and the likelihood of repayment on loan and interest. Included in the total investment of a project are the financial opportunity costs of any existing facilities that are integrated into the new project. The historical costs of existing assets are irrelevant to the banker. The banker typically has first claim to the project's assets and net cash flows, so the banker's net cash flow is the project's gross receipts net of operating and investment expenditures.⁷

3.5.2 The Owner's Point of View

The owner of a project examines the incremental net cash flow from the investment relative to what could have been earned in the absence of the project. Unlike the banker, the owner adds the loan to the net cash flows from the total investment point of view as cash receipt, and subtracts payments of interest and loan repayment as cash outlays. If the project receives any grants or subsidies from the government, these should be included as receipts in the cash

⁷ In few cases a subtle difference may exist between the point of view of total invested capital and the banker's point of view. Consider, for example, a government department that is encouraging the construction of low-income housing projects by repaying the interest on the housing loan. An analysis from the total invested capital point of view will not be concerned with the loan at all whether subsidized or not. A banker, however, will be definitely more in favor of loaning to a project that receives a government loan subsidy than a similar project that does not receive the subsidy.

flow statement. Therefore, the only difference between the analysis from the owner's point of view and that from the banker's point of view is financing.

3.5.3 The Government's Point of View

A project may require outlays from the government budget in the form of cheap credit, subsidies, grants or other transfer payments and may also generate revenues from direct or indirect taxes and fees. The analysis from the government's point of view is to ensure that the relevant government ministries have enough resources to finance its obligations to the project. If the ministry is the project owner, then the distinction between the cash flow statements from the owner's and the government point of view is the difference in their opportunity costs of funds. If, on the other hand, the government's involvement is in the form of receiving taxes and/or providing some cheap credit, subsidies, or grants, then the cash flow statement from the government's point of view will reflect these transactions.

Although the three views outlined above are the most typical points of view considered when conducting the financial analysis, it is important to analyze the impacts of the project on all involved parties. For example, if the project under consideration is likely to have a negative impact on competitors, one should anticipate their reactions and proper adjustments. It is thus necessary to estimate and signify the magnitude of the negative impacts to any affected group. These affected groups could include competitors, suppliers of inputs, downstream processors, etc. as part of the stakeholders of the project.

3.5.4 The Country's Point of View

A project can be evaluated from the country's point of view, especially when the project is undertaken by the government or involved some form of government intervention. While undertaking the evaluation from the point of view of the entire country, economic prices must be used to value inputs and outputs in order to reflect their true resource cost or economic benefit to society. The economic prices take into account taxes, subsidies and other distortions in market place. From the country's point of view, the activities that had to

be foregone in undertaking the project should also be charged at real resource cost. Thus, the economic appraisal of a project adjusts the financial cash flow from the total investment viewpoint for taxes and subsidies and ignores loan and interest payments because these represent flow of funds, not real resources.

3.5.5 Relationship between Different Points of View

A project can be thought as a bundle of transactions that cause different individuals or institutions to incur different costs and receive different benefits. The evaluation of a project from several perspectives is critical because it allows the analyst to determine whether the parties involved will find it worthwhile to finance, join, or execute the project. If the outcome of a project is attractive to the owner but not to the financing institution or to the government's budget office, the project could face problems securing official approval and funding. Alternatively, if a project is attractive from the viewpoint of a banker or the budget office but unattractive to the owner, the project could face problems during implementation. In short, to insure approval and successful implementation a project must be attractive to all the investors and operators associated with the project.

To illustrate the different analyses available for evaluating a project, we provide an example of a project with the following stylized facts:

1. The project will last two years, labeled years 0 and 1. The project will be built during year 0, start operating at the beginning of year 1, and terminate at the end of year 1.
2. During year 0, \$1,000 is spent in the purchase of machinery.
3. To finance the project, the owner will require a loan from a private bank equivalent to 50% of the initial investment cost. The repayment on the interest and the principal of the loan is due in year 1. The loan carries a 10% interest.
4. The project generates \$300 in sales in year 1 and receives a subsidy equivalent to 50% of the sales value. Operating costs are \$140 in year 1. Taxes amount to \$100.
5. The project sells its equipment at the end of year 1 for \$950.
6. The project creates pollution. The cost of cleaning up the contaminated by the project

has been estimated at \$50 per year of operation. The government will not require the investor to clean up after the completion of the project.

7. The land for the project, currently owned by the developer of the project, has an opportunity cost as it could have been rented to others for \$30 per year.

The cash and/or resource flows of the project can be rearranged as viewed by different actors such as the owner, banker, government budget office, and the country as a whole following different accounting conventions. This is presented in Table 3.4.

Table 3.4: Net Resource Flow from Different Viewpoints (Dollars)

Viewpoints:	<u>Financial Analysis</u>						<u>Economic Analysis</u>	
	<u>Owner</u>		<u>Bank</u>		<u>Government</u>		<u>Country</u>	
Year:	0	1	0	1	0	1	0	1
Sales		300		300				300
Operation Cost		-140		-140				-140
Equipment	-1,000	950	-1,000	950			-1,000	950
Subsidy		150		150		-150		
Taxes		-100		-100		100		
Loan	500	-500						
Interest		-50						
Externality								-50
Opportunity Cost of Land	-30	-30	-30	-30			-30	-30
Net Resource Flow	-530	580	-1,030	1,130		-50	-1,030	1,030

The returns of this project differ from alternative viewpoints. Moreover, the analysis of the project from a financial and an economic perspective and from the viewpoints of the owner and the country can lead to four possible results, as shown in Figure 3.2.

In cell (A), the project ought to be undertaken because it generates net benefits to the owner and to the country. In cell (D), the project generates net losses to both parties and, consequently, should not be undertaken. In between, one finds cases where the owners are motivated to take actions that are not consistent with the action that is best for the economy. In cell (B) the project is profitable to the owner, but generates loss to the society. This may

occur for project such as cultivation of a crop with extensive pesticides, which may harm people living in the project area. If the government increases its taxation of this activity, owners may find it unprofitable to invest in the project. If the government imposes taxes, the activity will shift from cell (B) to cell (D). In this case, the project should not be undertaken if it is unprofitable to society.

Figure 3.2: Profitability Calculations from Owner’s and Economy’s View

		<i>Economic (country)</i>	
		+	(-)
<i>Financial</i>	+	(A)	(B)
<i>(owner)</i>	(-)	(C)	(D)

In cell (C), the project generates net economic benefits to society but net losses to the owners. Consequently, equity holders will not endorse or undertake the project on their own. Such an activity may include the cultivation of trees, which enhance watershed protection, bio-diversity, and erosion control. Although these services benefit society, they do not generate enough income to the private owner. If the government provides subsidies in order to lure investors to participate in the activity, the project will shift from being a cell (C) type activity to being a cell (A) type activity. In such a situation, it is both socially profitable and the owners will have an incentive to undertake the project.

From this analysis, we can see how important it is to have projects that are attractive from both the financial as well as society's point of view. In order for socially profitable projects to be implemented, they must be designed to be financially viable. On the other hand, projects those are financially attractive but have negative economic returns will cause damage to the economy and are worse than doing nothing.

3.6 Conclusion

This chapter begins with the presentation of the main concepts, principles and conventions involved in the development of pro-forma financial statements of an investment project. As projects usually last for many years, forecasts of capital investment, quantities and prices of inputs and outputs over the life of the project are uncertain but such projections are necessary for the financial analysis of its commercial viability.

We have described the process to make projections consistently over the life of the project. These include the movement of the real and nominal prices of inputs and outputs of the project, nominal interest rates and the nominal exchange rate that are projected in a way that is consistent with expectations about the future rate of inflation.

Finally an investment project often involves different stakeholders. Each will be concerned with the impact the project will have on them. To ensure the project's sustainability, the assessment of projects from different points of view is needed to minimize the adverse effect perceived by any of the stakeholders.

Appendix 3A

Steps in Constructing the Pro Forma Cash Flow Statements

The data requirements for conducting a project appraisal have been outlined in Chapter 3. This appendix will provide a practical approach to constructing the financial cash flow statement starting from the very beginning. The construction of a cash flow statement requires that the data be organized in a number of preparatory tables in Excel that culminate in the cash flow statement.

1. All project parameters are extracted from the project documents and placed in the Table of Parameters. The table of Parameters includes all the raw data that the construction of the cash flow statements will require. This will include prices, costs, production coefficients, financing terms, inflation and exchange rates, depreciation rates, working capital and all other data that will be used in the analysis. It is imperative that all data entry in the spreadsheet be completed in the Table of parameters. The construction of all other tables should be based on formulas and equations that are linked to the data in the Table of Parameters. This is crucial to maintain the integrity of the spreadsheets for sensitivity and risk analyses.
2. After all the required data have been recorded in the Table of Parameters, a table of inflation and exchange rates is constructed. In this table, we develop domestic inflation and foreign inflation indices for the life of the project. These indices are based on the expected rates of domestic and foreign inflation. The table also contains a relative inflation index that measures the change in the general price level of the domestic currency relative to the foreign currency. It is used to determine the nominal exchange rate over the life of the project. There will be no need for including exchange rates if none of the project's inputs are imported and none of its outputs are exported. The reference year for estimating inflation is usually taken as the first year of the project's life for convenience. As a result, the relative inflation index for the first year of the project will be equal to 1.00. Typically, the project analyst takes the real exchange rate

as constant; the nominal exchange rate is only affected by the relative change in the inflation rates of the domestic and foreign currencies.

3. The next table(s) will contain all the data on sales and purchases. It will be used to estimate the unit cost of production. On the sales side, quantities produced and quantities sold are introduced. The expected sales prices over the life of the project should be determined. Quantities sold should be multiplied by nominal prices to generate revenues. To determine the nominal price of an item, we first include changes in real prices, if any are expected, and then apply the inflation index. If the sales are for the domestic market, the prices expressed in domestic currency and the domestic inflation index should be applied. If we are dealing with exports and the prices are expressed in foreign currency, then the foreign inflation index should first be applied to the real prices and then the result is multiplied by the projected market exchange rate. Prices of all inputs are determined in exactly the same manner. This includes labor of all types, and overheads. Total costs are aggregated and divided by the total quantity produced to determine the unit cost of production.
4. The next step is to estimate the cost of good sold, that is used in the income tax statement to determine the project's income tax liability. Based on the inventory policy followed by the project and whether FIFO or LIFO, or any other accounting method is used, physical units sold are identified in terms of when they were produced and the respective cost of production is applied to each unit. For example, if all of a year's sales were produced in the same year, then the unit cost of production of the year is the relevant one. If however, only 70% of the sales of this year were produced this year, with the balance produced the previous year, then the costs of goods sold will be determined by multiplying 70% of the sales by the unit cost of production of this year, and the remaining 30% by the unit cost of production of the previous year.
5. The working capital table typically includes two sections. The first section includes the impacts of working capital on the cash flow statements of the project. This includes the changes in accounts receivable, changes in accounts payable and changes in cash

balances. Accounts receivable, accounts payable and cash balances are typically based on the amount of sales or purchases and should be linked to nominal sales and/or purchases. In the second section, the project analyst will estimate the initial working capital requirements for the project. This will be either financed through equity or through debt.

6. The investment and depreciation schedule is prepared next. This table includes all investment data. The prices should be expressed in nominal terms. This table serves two purposes. The first is to determine the depreciation expense that will be included in the income tax statement that is used to determine the income tax liability. In this case, the rate of depreciation used is specified by the tax and accounting rules. The second purpose is to develop residual values for the project's assets. These are typically based on economic rates of depreciation for the depreciable assets. The economic rate of depreciation will be applied to the value of the asset in the year it was acquired. In this study the residual values obtained will be in the purchasing power of the year of acquisition. Since we construct the cash flow statement in nominal prices before deflating it to real prices, the residual values expressed in the purchasing power of the year of acquisition are adjusted to reflect the increase in price level over the life of the project.

Land is typically an undepreciable asset. It will be adjusted for inflation only to arrive at the value of the land in nominal prices in the final year of the project.

7. The financing schedule typically includes all the loans by date of disbursement. Repayments of financing cost are estimated using nominal interest rates and broken down by interest and principal. Interest expense is used in the income statement to help determine the tax liability of the project. If the loan is denominated in foreign currency and will be paid back in foreign currency, then the entire repayment schedule should be worked out in foreign currency. The loan and repayment flows are then converted into domestic currency using the nominal exchange rates.

8. If the project is to pay taxes, then an income statement should be constructed. The income tax statement is constructed in nominal terms. The costs of goods sold, depreciation and amortization expenses, overheads, and interest expense that have been prepared earlier are all subtracted from nominal sales. Net taxable income is then derived and the tax liability determined. The income tax liability is used in the cash flow statement, which is constructed in the next step.

9. All the ingredients of the cash flow statement have been prepared. The only thing left is to assemble these components to construct the cash flow statement. We start with the cash flow statement from the point of view of total invested capital.
 - Nominal cash receipts are typically made up of the following: sales and changes in accounts receivable to adjust for credit sales, and the residual values of the project's assets. All receipts inclusive of VAT and other sales taxes are added up for each year to determine annual cash inflows.
 - Nominal expenditures are broken down into investment expenditures and operating expenditures and included in the cash flow statement. If the project is using any existing assets the opportunity cost of these assets should be included with the investment expenditures. Nominal operating expenditures inclusive of VAT and other sales taxes are included in the cash flows. Changes in the cash balance and accounts payable should also be included. Finally, the income tax liability is also part of the cash outflows. All expenditures are added up for each year to determine annual cash outflows.
 - VATs on sales are collected on behalf of the tax authority and VAT paid on purchases can be claimed as input tax credit. Thus, the amount of VAT collected in excess of input tax credit should be deducted as a cash outflow from the project.
 - Nominal net cash flows are derived by subtracting the nominal cash outflows from the nominal cash inflows and adjusting for net VAT collected.

10. The cash flow statement in nominal prices from the owner's point of view is constructed by adding the debt as inflows and interest and principal repayment as outflows to the cash flow statement estimated from the viewpoint of total invested capital.

11. The cash flow statements in real prices from the owner's point of view are estimated by deflating each item in the nominal cash flow statement by the corresponding inflation index for the year.

Appendix 3B

Impacts of Inflation on Financial Cash Flows

The effects of inflation on a project's financial condition include: a) direct impacts from changes in investment financing, cash balances, accounts receivable, accounts payable and nominal interest rates, b) tax impacts including interest expenses, depreciation and inventories, and c) the impact on the market exchange rate. Inflation alters the amount and timing of the financial gains and losses of the various parties involved in a project including the owner, the lender and the government. Correctly accounting for those changes is necessary to determine how the overall project, and each of the interested parties, is affected by different levels of inflation.

3B.1 Direct Effects

(a) Investment Financing

When estimating the amount of financing a project requires, it is important to distinguish between two types of cost increases. First, there are cost over-runs which are caused by incorrect estimates of the quantities of materials required or changes in the real prices of those materials. Second, there is cost escalation which is attributable to general price level inflation. The "escalation" of costs that stems from pure price inflation should be recognized as normal and, if possible, should be anticipated and included in the project appraisal. If the project requires a loan or equity financing for future outlays, it should be recognized that the amount of financing needed will be affected by the amount of price inflation that takes place during the time of construction. Cost increases attributable to inflation are not overruns of real costs; therefore, additional borrowing that simply reflects the rise in the general level of prices should be planned for. If this condition is not adequately planned for at the appraisal stage, the project may experience a liquidity crisis or insolvency due to inadequate financing.

Table 3B.1 demonstrates the effects of inflation on investment financing. All values are given in dollars. The project will be built during the first two periods, operate for following four, and then be liquidated in the final period. The total cost of construction will be

capitalized at the end of the second period to determine the amount to be depreciated. Loans are obtained for 50% of the investment in fixed assets. Loan financing will have a nominal interest rate of 5 percent per period if there is no inflation, and interest will begin accruing during the construction period. The loan principal will be repaid at the end of the last operating year of the project, period 5. The remainder of the financing requirements is covered by the owners' equity.

In this project an investment of \$5,000 is made in fixed assets in year 0, and if there is no inflation, a further \$5,000 is made in year 1. If there is 25% inflation a year, the initial year's investment does not change, however, the nominal investment undertaken in year 1 increases to \$6,250.

Table 3B.1 Project XYZ Financing

Period	0	1	2	3	4	5	6
Inflation = 0%							
1. Price Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2. Investment Outlays	5,000	5,000	0	0	0	0	0
Inflation = 25%							
3. Price Index	1.00	1.25	1.56	1.95	2.44	3.05	3.81
4. Investment Outlays	5,000	6,250	0	0	0	0	0
5. Impact on Financing Requirements	0	1,250	0	0	0	0	0

The presence of inflation increases the nominal amount of the investment financing required by \$1,250 even when there is no increase in its material needs or costs. For a 25 percent inflation rate, total nominal project costs increased from \$10,000 to \$11,250, or by 12.5 percent. The increased investment expense has three effects. First, it increases the interest costs to the project. Second, it increases the nominal amount of loan principal (50% of nominal investment costs) which must be repaid by the project. Finally, it results in a larger nominal depreciable expense that will be deductible from future taxes. These effects have both positive and negative cash flow impacts which are discussed below.

(b) Desired Cash Balances

Cash balances are held by a project to facilitate transactions. A commercial enterprise will need to maintain an amount of cash on hand that is related to the value of sales and purchases they carry out. In addition, lenders may require that a substantial amount of cash balances or

very liquid assets be held in a debt reserve account. If the demand for cash balances is a function only of the level of sales and sales remain constant with no inflation, then after initially setting aside the desired amount of operating cash, no further investments in the cash balances would be required. However, when there is inflation, the sales, receipts, and the cost of the goods purchased will go up even if the quantities of goods bought and sold remain the same. The resulting loss in the purchasing power of cash balances is referred to as an "inflation tax" on cash holdings.⁸ Its primary effect is to transfer financial resources from the project to the banking sector. In such a situation, the project either will have to increase its cash balances in order to conduct operations or to substitute more physical resources to carry out these transactions.

The effects of an inflation tax on cash balances can be demonstrated using a simple comparison of two cases. The first case shows the cash situation for a project operating in an environment where there is no inflation. Sales will be \$2,000 for each period from 2 through 5, and the desired cash balance is equal to 10 percent of the nominal value of sales. Hence, given the absence of inflation, after the initial \$200 is placed in the cash account, there is no need to increase that balance. The present value of the cost of holding cash by the project is -\$41 (Table 3B.2, line 6).

Table 3B.2 Project XYZ Cash Balance

Period	0	1	2	3	4	5	6
Inflation = 0%; Desired cash balance = 10% of sales							
1. Price Index	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2. Sales	0	0	2,000	2,000	2,000	2,000	0
3. Desired Cash Balance	0	0	200	200	200	200	0
4. Change in Cash Balance	0	0	(200)	0	0	0	200
5. Real cash flow impact [4/1]	0	0	(200)	0	0	0	200
6. PV of holding cash @ 7%=							(41)

However, if the inflation rate increases to 25 percent per period, the cash balances must be increased to keep abreast of the increasing nominal value of sales. We assume for the purpose of this example that the number of units sold remains the same but their nominal value increases by 25% a year due to inflation. As a result, the desired stock of cash balances will increase, requiring an additional investment of cash in the project during each period if

⁸ Jenkins, G.P., *Inflation: Its Financial Impact on Business in Canada*, Ottawa: Economic Council of Canada, Special Study Series, (1979).

the desired level is to be maintained (Table 3B.3, row 4). After deflating these costs for inflation and discounting them, we find that the PV of the cost of the cash needed to run the business has increased substantially.

Table 3B.3 Cash Balance with 25% Inflation

Period	0	1	2	3	4	5	6
Inflation = 25%; Desired cash balance = 10% of sales							
1. Price Index	1.00	1.25	1.56	1.95	2.44	3.05	3.81
2. Sales	0	0	3,125	3,906	4,883	6,104	0
3. Desired Cash Balance	0	0	313	391	488	610	0
4. Change in Cash Balance	0	0	(313)	(78)	(98)	(122)	610
5. Real cash flow impact [4/1]	0	0	(200)	(40)	(40)	(40)	160
6. PV of holding cash @ 7% = (159)							

With zero inflation in Table 3B.2, the PV of the cost of holding real cash balances was -\$41. However, when the inflation rate is 25 percent, the PV of the cost of maintaining the same level of real cash balances will equal to -\$159 as shown in Table 3B.3, line 6. This 288 percent increase in the cost of holding cash demonstrates clearly that in an inflationary environment the need to continuously add to the stock of cash balances will add to the real costs of the project. Hence, project evaluators should incorporate a number of inflation projections in order to determine the sensitivity of total costs to the impact of inflation on the cost of holding the desired level of real cash balances.

(c) Accounts Receivable

Accounts receivable arise from making credit sales. When goods are sold and delivered but the enterprise is still awaiting payment, the value of this sale is added to accounts receivable. Such credit sales are part of the normal process of conducting business. However, in the presence of inflation, the real value of the amounts that are owed to the seller decrease the longer they are left unpaid. This creates an additional financial problem for the management of the enterprise, because they must be concerned not only with the normal risk of default but also with the fact that the receivables are falling in real value the longer they are left unpaid.

Table 3B.4 demonstrates the interaction between inflation and accounts receivable and the impact that interaction has on cash receipts. As the inflation rate rises, the value of sales

increases due to the higher prices of the goods, even when the number of units sold remains unchanged. This generally leads to an increase in the amount of accounts receivable. In this case, it is assumed that receivables will be equal to 20% of sales.

Table 3B.4 Accounts Receivable

Period	0	1	2	3	4	5	6
Inflation = 0%							
1. Sales	0	0	2,000	2,000	2,000	2,000	0
2. Accounts Receivable	0	0	400	400	400	400	0
3. Change in A/R	0	0	(400)	0	0	0	400
4. Real Receipts [1+3]	0	0	1600	2000	2000	2000	400
Inflation = 25%							
5. Price Index	1.00	1.25	1.56	1.95	2.44	3.05	3.81
6. Sales	0	0	3,125	3,906	4,883	6,104	0
7. Accounts Receivable	0	0	625	781	977	1,221	0
8. Change in A/R	0	0	(625)	(156)	(195)	(244)	1,221
9. Nominal Receipts [6+8]	0	0	2,500	3,750	4,688	5,859	1,221
10. Real Receipts [9/5]	0	0	1,600	1,921	1,921	1,921	321
11. Change in Real Receipts [10-4]		0	0	(79)	(79)	(79)	(79)
12. PV of the change in real receipts @ 7% = (233)							

In spite of the fact that the nominal value of sales increases each period when there is 25 percent inflation, Table 3B.4 demonstrates that the PV of the real receipts for this project decreases by \$233 due to the higher rate of inflation. This is because inflation causes the real value of outstanding trade credit to fall. When this situation arises, businesses selling goods or services will attempt to reduce the length of the terms they give for trade credit, while businesses purchasing the product will have an additional incentive to delay payment. If sellers are not successful at reducing the terms they give for trade credit, they will have to increase the price of the goods they sell above what would be justified by the rate of inflation. Thus, it is important to include in a project evaluation the interaction of inflation and accounts receivable to determine how the real receipts of the business are affected by inflation.

(d) Accounts Payable

Accounts payable represent the amount of money owed by a business to others for goods or services already purchased and delivered. When there is inflation, the buyer with the accounts payable benefits from having an outstanding balance because the real value of the

obligation is falling during the period of time prior to the payment. This is simply the other side of the impact of inflation on accounts receivable because one enterprise's accounts receivable is another's accounts payable.

Table 3B.5 shows how inflation affects a project's financial situation when accounts payable are equal to 25% of annual purchases. Once again, we see that inflation increases the nominal value of purchases which leads to greater accounts payable as well. The increased rate of inflation results in a net decrease of \$155 in the PV of real expenditures. As shown in line 6, inflation increases the nominal value of purchases, and creates a corresponding increase in nominal accounts payable in line 7. When converted to real expenditures, the buyer (the project in this case) benefits from the effects of inflation on accounts payable and will have a lower overall level of expenditure, as shown in Table 3B.5, row 11. This gives the buyer an incentive to extend the terms of the accounts payable to benefit from their falling real value. Hence, in the presence of inflation, the longer the outstanding accounts payable are held before being paid, the greater the benefit accruing to the buyer.

Table 3B.5 Accounts Payable

Period	0	1	2	3	4	5	6
Inflation = 0%							
1. Purchases of Inputs	0	1,000	1,000	1,000	1,000	0	0
2. Accounts Payable	0	250	250	250	250	0	0
3. Change in A/P	0	(250)	0	0	0	250	0
4. Real Expenditures [1+3]	0	750	1,000	1,000	1,000	250	0
Inflation = 25%							
5. Price Index	1.00	1.25	1.56	1.95	2.44	3.05	3.81
6. Purchases	0	1,250	1,563	1,953	2,441	0	0
7. Accounts Payable	0	313	391	488	610	0	0
8. Change in A/P	0	(313)	(78)	(98)	(122)	610	0
9. Nominal expenditures [6+8]	0	937	1485	1855	2319	610	0
10. Real Expenditures [9/5]	0	750	951	951	951	201	0
11. Change in real expenditures [10-4]		0	(49)	(49)	(49)	(49)	0
12. PV of the change in real expenditures @ 7%=(155)							

(e) Nominal Interest Rates

Another way that inflation alters the real net financial condition of a project is through its impact on nominal interest rates. Lenders increase the nominal interest rate on the loans they give to compensate for the anticipated loss of the real value of the loan caused by inflation.

As the inflation rate increases, the nominal interest rate will be increased to ensure that the PV of the interest and principal payments will not fall below the initial value of the loan. This results in increased interest payments (in real terms) in the short term that compensate for the decreasing real value of the loan principal repayments over time.

The nominal interest rate i as determined by the financial markets is made up of three major components: a) a factor r which reflects the real time value of money that lenders require in order to be willing to forego consumption or other investment opportunities, b) a risk factor R which measures the compensation the lenders demand to cover the possibility of the borrower defaulting on the loan, and c) a factor $(1+r+R)gP^e$ which is compensation for the expected loss in purchasing power attributable to inflation. Inflation reduces the future value of both the loan repayments and real interest rate payments. The expected rate of inflation for each period of the loan is expressed as gP^e . Combining these factors, the nominal (market) rate of interest i can be expressed as:

$$i = r + R + (1 + r + R) gP^e \quad (3B.1)$$

For example, if the real interest rate (r) is 5 percent, the risk premium and inflation are zero, then the lender would charge at least 5 percent nominal interest. If the lender anticipates that the future rate of inflation (gP^e) will be 25 percent, however, then she would want to increase the nominal interest rate charged to the borrower in order to compensate for the loss in purchasing power of the future loan and interest rate payments. Maintaining the assumption that there is no risk to this loan, the lender will need to charge a nominal interest rate of at least 31.25% by applying equation (3B.1) to achieve the same level of return as in the zero inflation scenarios.⁹

For the project we are analyzing here, fixed assets investments are financed 50% by debt and 50% equity. All other investments such as initial supplies are financed 100% by equity. In

⁹ At this point the subsequent adjustment of interest rates brought about by the impact of the taxation of interest payments is ignored as is the impact of changes in net-of-tax interest rates on the demand and supply of loanable funds. For an excellent discussion of these issues see Feldstein, M., "Inflation, Income Taxes and the Rate of Interest: A Theoretical Analysis," *American Economic Review*, 66, No. 5 (Dec. 1976), pp. 809-820.

Tables 3B.6 and 3B.7, the loan schedule for the debt portion of the financing is calculated under the 0% and the 25% inflation rate scenarios.

Table 3B.6 Nominal Interest Rate of 5 percent

Period	0	1	2	3	4	5	6
Inflation = 0%							
1. Loan Principal	2,500	2,500	0	0	0	0	0
2. Interest	0	(125)	(250)	(250)	(250)	(250)	0
3. Loan Repayment	0	0	0	0	0	(5,000)	0
4. Real cash flow [1+2+3]	2,500	2,375	(250)	(250)	(250)	(5,250)	0
5. PV @ 5%= 0							

From the discussions above, we know that the higher rate of inflation will increase both the nominal investment required and the nominal interest rate. The higher initial capital requirement must be repaid at the higher nominal interest rate as shown in Table 3B.7.

Table 3B.7 Nominal Interest Rate of 31.25 percent

Period	0	1	2	3	4	5	6
Inflation = 25%							
1. Price Index	1.00	1.25	1.56	1.95	2.44	3.05	3.81
2. Loan Principal	2,500	3,125	0	0	0	0	0
3. Interest	0	(781.3)	(1,757.8)	(1,757.8)	(1,757.8)	(1,757.8)	0
4. Loan Repayment	0	0	0	0	0	(5,625.0)	
5. Nominal cash flow [2+3+4]	2,500	2,343.7	(1,757.8)	(1,757.8)	(1,757.8)	(7,382.8)	0
6. Real cash flow [5/1]	2,500	1,875.0	(1,126.8)	(901.4)	(720.4)	(2420.6)	0
7. PV @ 5%= 0							

Comparing Tables 3B.6 and 3B.7, we find that the PVs of both loans are the same. This demonstrates that a loan with a 31.25% interest rate when inflation is 25 percent has the same PV as a loan with an interest rate of 5% when inflation is zero. The crucial differences are between the timing and amount of repayment. The higher nominal interest rate of 31.25% and higher inflation forces the project to repay its loans faster than if the inflation rate and nominal interest rates were lower. Table 3B.8 shows the difference between the project's cash flow in the two scenarios.

Table 3B.8 Comparison of Real Cash Flows

Period	0	1	2	3	4	5	6
1. 31.25% interest with 25% inflation	2500	1875	(1126.8)	(901.4)	(720.4)	(2420.6)	0
2. 5% interest with 0% inflation	2500	2375	(250.0)	(250.0)	(250.0)	(5250.0)	0
3. Difference in Real cash flow [1-2]	0	(500)	(876.8)	(651.4)	(470.4)	2829.4	0

In real terms, the higher nominal interest rate increases the cash outflows (or reduces the net cash inflows) of the project during periods 1-4 but decreases the value of the principal that is due at the end of the project by \$2,829.4. This is important to the evaluation of the sustainability of a project because the higher outflows during the early years of the repayment period could cause liquidity problems for the project if it is not generating sufficient cash inflows.

3B.2 Effect on Tax Related Factors

Inflation has three impacts on the tax liabilities of a project. First, the higher interest payments shown in the previous section increase the amount of tax deduction. Second, inflation reduces the value of the depreciation allowances taken for earlier investments in the project. Finally, the method used to account for inventory has an effect on the nominal earnings that are used to determine the taxable income. These three effects offset each other somewhat.

(a) Interest Deduction

Inflation can alter the financial feasibility of a project through the impact that increased nominal interest payments have on the income tax liabilities of the enterprise. In most countries, interest payments are deductible from income for the calculation of taxes, while principal repayments are not deductible. When the expected rate of inflation increases, nominal interest rates rise in order to compensate the lender for the loss in the purchasing power of the principal outstanding and future interest payments. Table 3B.9 shows how inflation, through the way it converts some of the real value of the principal repayments into interest payments, causes tax payments to fall. The higher nominal interest payments are

deductible from taxable income, hence they serve to reduce the amount of taxes which the project would otherwise be required to pay.

Table 3B.9 Interest Expense

Income Tax Rate = 30%

Period	0	1	2	3	4	5	6
Inflation = 0%; Nominal Interest = 5%							
1. Interest Expense	0	(125)	(250)	(250)	(250)	(250)	0
2. Real Tax Savings [row 1*.3]	0	37.5	75	75	75	75	0
Inflation = 25%; Nominal Interest = 31.25%							
3. Interest Expense	0	(781.3)	(1,758)	(1,758)	(1,758)	(1,758)	0
4. Tax Savings [row 3*0.3]	0	234	527	527	527	527	0
5. Price Index	1.00	1.25	1.56	1.95	2.44	3.05	3.81
6. Real Tax Savings [4/5]	0	187.2	337.8	270.3	215.9	172.8	0
7. Change in Tax Savings [6-2]	0	149.7	262.8	195.3	140.9	97.8	0
8. PV of increased tax savings @ 7% = 706							

(b) Depreciation Allowance

Another factor affected by inflation is the real value of the depreciation allowances for capital goods which are deductible for income tax purposes. Most countries base the deductions for depreciation expense (capital cost allowances) on the original nominal cost of the depreciable assets. If inflation increases, then the relative value of this deduction will fall causing the real amount of income tax liabilities to increase. In Table 3B.10, we see that a 25 percent rate of inflation causes the tax savings from depreciation expense deductions to fall by R1,090. This is equal to approximately 10 percent of the real value of the fixed assets being depreciated.

Table 3B.10 Project XYZ: Depreciation Allowance

Straight Line Depreciation over 4 periods; Income Tax Rate = 30%

Period	0	1	2	3	4	5	6
Inflation = 0%; Depreciable Investment = 10,000							
1. Depreciation	0	0	2,500	2,500	2,500	2,500	0
2. Real Tax Savings [row 1*0.3]	0	0	750	750	750	750	0
Inflation = 25%; Nominal Depreciable Investment = 11,250							
3. Depreciation	0	0	2812.5	2812.5	2812.5	2812.5	0
4. Tax Savings [row 3*0.3]	0	0	844	844	844	844	0
5. Price Index	1.00	1.25	1.56	1.95	2.44	3.053	81
6. Real Tax Savings [4/5]	0	0	541	433	346	276	0
7. Change in Real Tax Savings [6-2]	0	0	(209)	(317)	(404)	(474)	0
8. PV of change in real Tax Savings @ 7% = (1090)							

(c) Inventory Accounting

(i) First-In-First-Out (FIFO)

Further tax implications of inflation are experienced by commercial enterprises which must account for inventories of inputs and outputs. In many countries to determine the amount of taxable profit companies are required to value inventories in their accounts on a first-in-first-out basis (FIFO). This means that the price of the oldest inventories (first in) is the value which is used to determine the cost of the goods sold (COGS). The difference between the COGS and the sale price is the taxable revenue from the project.

Table 3B.11 Inventory and Cost of Goods Sold - FIFO

Income Tax Rate = 30%

Period	0	1	2	3	4	5	6
Inflation = 0%							
1. Sales	0	0	2,000	2,000	2,000	2,000	0
2. Purchase of Inputs	0	1,000	1,000	1,000	1,000	0	0
3. COGS	0	0	1,000	1,000	1,000	1,000	
4. Measured Profits [1 - 3]	0	0	1,000	1,000	1,000	1,000	0
5. Real Tax Liability [4*0.3]	0	0	300	300	300	300	0
Inflation = 25%							
6. Sales	0	0	3,125	3,906	4,883	6,104	0
7. Purchase of Inputs	0	1,250	1,563	1,953	2,441	0	0
8. COGS	0	0	1,250	1,563	1,953	2,441	0
9. Measured Profits [6 - 8]	0	0	1,875	2,343	2,930	3,663	0
10. Nominal Tax Liability [9*0.3]	0	0	563	703	879	1,099	0
11. Price Index	1.00	1.25	1.56	1.95	2.44	3.05	3.81
12. Real Tax Liability [10/11]	0	0	361	361	361	361	0
13. Change in tax liability [12-5]	0	0	61	61	61	61	0
14. PV of change in tax liability @ 7% = 193							

The real value of taxable income generally increases by the rate of inflation because sale prices are affected immediately by the rate of inflation, while the costs of goods sold from inventories are valued using prices of a previous period when the nominal prices were presumably lower. For example, if the project has a one year inventory of final goods at the beginning of the year and the inflation rate for that year is 25 percent, then nominal cost prices of the goods sold will be 25 percent lower than their selling prices one year later. The result is that the measured profits are artificially inflated which increases the tax burden in both nominal and real terms.¹⁰ From Table 3B.11, row 12 and row 5, we see that by increasing the rate of inflation from 0 to 25 percent, the PV of real tax payments increases by \$193.

(ii) Last-In-First-Out (LIFO)

Another system for accounting for the cost of goods sold is known as last-in-first-out (LIFO). As the name implies, the most recent goods purchased (last in) are used to measure the cost of goods sold (first out), and the prices of the project inputs are generally increasing

¹⁰ In 1974, this effect of inflation alone caused corporate taxable income in Canada to be overestimated by more than 30 percent. See Jenkins, G.P., op. cit., Chapter 2.

at the same rate of inflation as the outputs sold. During the production cycle of a project, this is a benefit because the profits are not increased artificially by the presence of inflation. It also means that taxes will be lower as a result. However, LIFO has a negative aspect as well because as the activity winds down, the level of inventories is reduced. The lower prices of the goods that were purchased in earlier years are now used to calculate the cost of goods sold, resulting in inflated profits and increased taxes as shown in Table 3B.12, row 13. In real terms, the tax burden increased by \$177 in period 5 over the no inflation scenario.

Table 3B.12 Inventory and Cost of goods Sold - LIFO

Income Tax Rate = 30%

Period	0	1	2	3	4	5	6
Inflation = 0%							
1. Sales	0	0	2000	2000	2000	2000	0
2. Purchase of Inputs	0	1000	1000	1000	1000	0	0
3. COGS	0	0	1000	1000	1000	1000	
4. Measured Profits [1-3]	0	0	1000	1000	1000	1000	0
5. Real Tax Liability [4*0.3]	0	0	300	300	300	300	0
Inflation = 25%							
6. Sales	0	0	3125	3906	4883	6104	0
7. Purchase of Inputs	0	1250	1563	1953	2441	0	0
8. COGS	0	0	1563	1953	2441	1250	0
9. Measured Profits [6-8]	0	0	1562	1953	2441	4854	0
10. Nominal Tax Liability	0	0	469	586	732	1456	0
11. Price Index	1.00	1.25	1.56	1.95	2.44	3.05	3.81
12. Real Tax Liability [10/11]	0	0	300	300	300	477	0
13. Change in tax liability [12-5]	0	0	0	0	0	177	0
14. PV of change in taxes due @ 7% =126							

Comparing the effects of inflation on the tax liability in the FIFO and LIFO accounting systems, we see that in both cases, inflation increased the taxes. With FIFO and 25 percent inflation the PV of the tax liability increased by \$193 (Table 3B.11), and with LIFO, the PV increased by \$126 (Table 3B.12).

In addition to the cost difference, the timing of the tax burden is substantially different. Using FIFO, inflation increased the taxes in each period, whereas using LIFO results in no increase in taxes in the production period but in a larger tax liability in the last sales period. LIFO defers the increased tax burden attributable to inflation until a period when there is a need to lower the level of inventories. As the lower priced inventories are drawn into the cost of goods sold, the difference between inflated sales values and older prices generates larger

profits and increases the tax liability. Using LIFO could increase the overall risk associated with the project in a high inflation environment if the reason for the enterprise wanting to lower the level of inventories was financial stress or business slow down. In such a situation, the increased tax liability is concentrated in a few periods when the project is already facing problems, while with FIFO the increased tax liability is spread out over each operating period. Hence, when doing the appraisal it is important to consider the type of accounting rules used for determining the cost of goods sold to assess how inflation might affect both the timing and quantity of the tax liabilities to be paid by the project.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 4:**

*DISCOUNTING AND ALTERNATIVE
INVESTMENT CRITERIA*

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ABSTRACT

This chapter discusses the alternative investment criteria commonly used in the appraisal of investment projects. The net present value (NPV) of a project criterion is widely accepted by accountants, financial analysts, and economists as the one that yields the correct project choices in all circumstances. However, some decision makers have frequently relied upon other criteria such as the internal rate of return, the benefit-cost ratio, the pay-back period and the debt service capacity ratio. The strengths and weaknesses of these criteria are examined in this chapter in order to demonstrate why the NPV criterion is the most reliable.

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CHAPTER 4

DISCOUNTING AND ALTERNATIVE INVESTMENT CRITERIA

4.1 Introduction

This chapter discusses the alternative investment criteria commonly used in the appraisal of investment projects. The net present value (NPV) of a project criterion is widely accepted by accountants, financial analysts, and economists as the one that yields the correct project choices in all circumstances. However, some decision makers have frequently relied upon other criteria such as the internal rate of return, the benefit-cost ratio, the pay-back period and the debt service capacity ratio. The strengths and weaknesses of these criteria are examined in this chapter in order to demonstrate why the NPV criterion is the most reliable.

Section 4.2 explains the concept of discounting and discusses the choice of discount rate. Section 4.3 elaborates and compares alternative investment criteria for the appraisal investment projects. Conclusions are made in the last section.

4.2 Time Dimension of a Project

Investment decisions are fundamentally different from consumption decisions. For example, fixed assets such as land and capital equipment are purchased at one point in time, and they are expected to generate net cash flows, or net economic benefits, over a number of subsequent years. To determine whether the investment is worthwhile, it is necessary to compare its benefits and costs with alternative projects, which may occur at different time periods. A dollar spent or received today is worth more than a dollar spent or received in a later time period. It is not possible just to add up the benefits and the costs of a project to see which is larger without taking account of the fact that amounts spent on investment today are worth more today than the same amount received as a benefit in the future.

The time dimension of a project's net cash flows and net economic benefits can be captured by expressing the values in terms of either future or present values. When moving forward in time to compute future values, analysts must allow for the compounding of interest rates. On the other hand, when bringing future values back to the present for comparison purposes, it is necessary to discount them. Discounting is just the inverse of compounding.

4.2.1 Time Value of Money

Time enhances the value of a dollar today and erodes the value of a dollar spent or received in the future. It is necessary to compensate individuals for forgoing their consumption today or lending their funds to a bank. In turn, banks and other financial institutions have to offer lenders interest in order to induce them to part temporarily with their funds. If the annual market interest rate is 5%, then 1 dollar today would be worth 1.05 dollars that are received one year in the future. This means that in equilibrium lenders value 1.05 dollars in one year's time, the same as 1 dollar today.

4.2.2 Compounding

There are two main ways that interest can be included in future values, simple interest and compound interest. Simple interest is paid on only the principal amount that is invested while compound interest is paid on both the principal and the interest as it accumulates. Compound interest, which is the most commonly used way of charging interest, can cause the future value of 1 dollar invested today to increase by substantially more than simple interest over time. The difference is caused by the interest on the cumulative interest. The formula for compound interest payment is $V_t = (1+r)^t$ where V_t stands for the value in year t with 1 dollar received in year zero and r denotes the rate of interest.

Interest may be compounded annually. It is common, however, for interest to be compounded more frequently, e.g., semi-annually, quarterly, monthly or even daily. The number of compounding intervals will also affect the future value of an amount of cash

invested today. Thus the two factors affecting the future value of a dollar invested today are the time period of the investment and the interest rate.

Furthermore, when comparing two debt contracts it is essential that they be judged on the basis of equivalent rates -- e.g., annual rates in the case of loan agreements, semi-annual rates in the case of bonds. The magnitude of the interest rate is certainly a major determinant of the future value of series of a cash flow item.

4.2.3 Discounting

The discount factor allows us to compute the present value of a dollar received or paid in the future. Since we are moving backward, rather than forward in time, the discount factor is the inverse of the compound interest factor. For example, an amount of 1 dollar now will, if invested, grow to $(1+r)$ a year later. It follows that an amount B to be received in n years in the future will have a present value of $B/(1+r)^n$. The greater the rate of discount used, the smaller is its present value.

The nature of investment projects is such that their benefits and costs usually occur in different periods over time. The NPV of a future stream of net benefits, $(B_0 - C_0)$, $(B_1 - C_1)$, $(B_2 - C_2)$, . . . , $(B_n - C_n)$, can be expressed algebraically as follows:

$$\begin{aligned} NPV^0 &= \frac{B_0 - C_0}{(1+r)^0} + \frac{B_1 - C_1}{(1+r)^1} + \dots + \frac{B_n - C_n}{(1+r)^n} \\ &= \sum_{t=0}^n \frac{(B_t - C_t)}{(1+r)^t} \end{aligned} \quad (4.1)$$

where “ n ” denotes the length of life of the project. The expression $1/(1+r)^t$ is commonly referred to as the discount factor for year t .

For purposes of illustration, the present value of the stream of net benefits over the life of an investment is calculated in Table 4.1 by multiplying the discount factors, given in row 4, by

the values of the net benefits for the corresponding periods shown in row 3. The NPV of \$1,000 is the simple sum of the present values of net benefits arising each period throughout the life of the project.

Table 4.1 Calculating the Present Value of Net Benefits from an Investment Project (Dollars)

Items	0	1	2	3	4	5
1. Benefits			3,247	4,571	3,525	2,339
2. Costs	5,000	2,121	1,000	1,000	1,000	1,000
3. Net Benefits (=1-2)	-5,000	-2,121	+2,247	+3,571	+2,525	+1,339
4. Discount Factor at 6% (=1/(1+r) ^t)	1.000	0.943	0.890	0.840	0.792	0.747
5. Present values (=4*3)	-5,000	-2,000	+2,000	+3,000	+2,000	+1,000
6. Net Present Value	1,000					

Equation (4.1) shows that the net benefits arising during the project's life are discounted to period zero. Instead of discounting all the net benefit flows to the initial year of a project, we could evaluate the project's stream of net benefits as of a year k , which does not even need to fall within the project's expected life. In this case all the net benefits arising from year zero to year k must be cumulated forward at a rate of r to period k . Likewise, all net benefits associated with years $k+1$ to n are discounted back to year k at the same rate r . The expression for the NPV as of period k becomes:

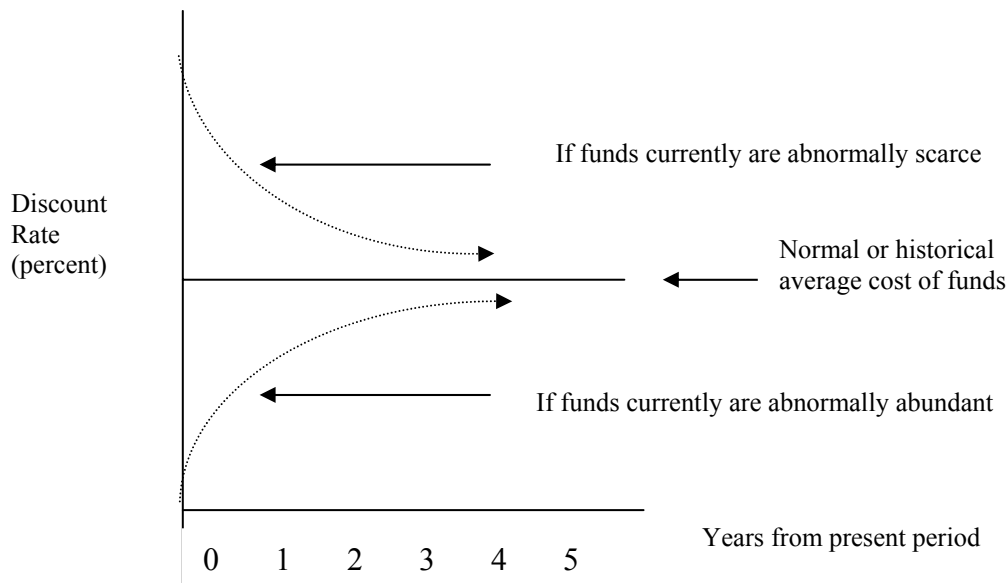
$$\begin{aligned}
 NPV^k &= \sum_{t=0}^n [(B_t - C_t) \cdot (1+r)^{k-t}] \\
 &= \sum_{t=0}^n [(B_t - C_t) / (1+r)^t] \cdot (1+r)^k
 \end{aligned} \tag{4.2}$$

The terms, $(1+r)^k$, is a constant value as it is a function of the discount rate and the date to which the present values are calculated. The rankings of alternative projects will not be altered if the project's net benefits are discounted to year k instead of year zero. The present values of their respective net benefits discounted at period zero are all multiplied by the same constant term. Hence the ranking of the net present values of the net benefits of the alternative projects will not be affected.

4.2.4 Variable Discount Rates

To this point we have assumed that the discount rate remains constant throughout the life of a project. This need not be the case. Suppose that funds are very scarce at present relative to the historical experience of the country. In such circumstances, we would expect to find that the cost of funds will currently be abnormally high and the discount rate will most likely fall over time as the supply and demand for funds return to normal. On the other hand, if funds are abundant at present, we would expect the cost of funds and the discount rate to be below their long-term average. In this case we would expect the discount rate to rise as the demand and supply of funds return to their long-term trend over time. This process is illustrated in Figure 4.1.

Figure 4.1 Adjustment of Cost of Funds through Time



Suppose that the discount rates will vary from period to period over the life of a four-year project. The discount rate r_1 is the cost of capital or the rate of discount extending from period zero to period one. The NPV of the project should be calculated as:

$$NPV^0 = (B_0 - C_0) + \frac{B_1 - C_1}{(1+r_1)} + \frac{B_2 - C_2}{(1+r_1)(1+r_2)} + \frac{B_3 - C_3}{(1+r_1)(1+r_2)(1+r_3)}$$

where r_1 , r_2 and r_3 are the discount rates for period 1, period 2 and period 3, respectively. Each discount factor after period two will be made up of more than one discount rate. For example, the discount factor for year three's net benefits is $1/[(1+r_1)(1+r_2)(1+r_3)]$. The general expression for the NPV of the project with a life of n years, evaluated as of year zero, becomes:

$$\text{NPV}^0 = (B_0 - C_0) + \sum_{i=1}^n \frac{B_i - C_i}{\prod_i (1 + r_i)} \quad (4.3)$$

As in the case of the constant rate of discount, when comparing two or more projects the period to which the net benefits of the projects are discounted does not matter provided that the present values of the net benefits of each of the projects being compared are discounted to the same date.

4.2.5 Choice of Discount Rate

The discount rate is a key variable in applying investment criteria for project selection. Its correct choice is critical given the fact that a small variation in its value may significantly alter the results of the analysis and affect the final choice of a project.

The discount rate, stated in simple terms, is the opportunity cost of funds that are invested in the project. In financial analysis, the discount rate depends upon the viewpoints of analysis. For instance, when a project is being appraised from the point of view of the equity holders, the relevant cost of funds is the return to equity that is being earned in its alternative use. Thus if the equity holders are earning a return of 15% on their current investments and decide to invest in a new project, the cost of funds or the discount rate from their perspective for the new project is 15%.

When we conduct the economic analysis of a project, the relevant discount rate is the economic opportunity cost of capital for the country. To estimate this cost we start with the capital market as the marginal source of funds we need to determine the ultimate sources of funds obtained via the capital market and estimate the respective cost of each source. The funds are generally drawn from three sources. First, funds that would have been invested in other investment activities have now been displaced by the project. The cost of these funds is the gross of tax return that would have been earned by the alternative investments, which are now foregone. Second, funds come from different categories of savers in the economy who postpone some of their consumption in the expectation of getting a return on their savings. The cost of this part of the funds is the cost of postponing this consumption. Third, some funds may be coming from abroad, that is from foreign savers. The cost of these funds is the marginal cost of foreign borrowing. Thus, the economic opportunity cost of capital will simply be a weighted average of the costs of funds from three alternative sources. The detailed methodology for measuring the economic opportunity cost of capital will be discussed later.

4.3 Alternative Investment Criteria

Different criteria have been used in the past to evaluate if an investment project is financially and economically viable. In this section, we review six of these criteria including the net present value, the internal rate of return, the benefit-cost ratio, the pay-out or pay-back period, the debt service coverage ratio, and cost-effectiveness.

4.3.1 Net Present Value Criterion

The NPV is the algebraic sum of the present values of the expected incremental net cash flows for a project over the project's anticipated lifetime. It measures the change in wealth created by the project.

(a) *When to Accept and Reject Projects*

If the NPV of the project is equal to zero, investors can expect to recover their incremental investment and also earn a rate of return on their capital that would have been earned elsewhere and is equal to the private discount rate used to compute the present values. This implies that investors would be neither worse off nor better off than they would have been if they had left the funds in the capital market. A positive NPV project means that investors can expect not only to recover their capital investment, but also to receive a rate of return on capital higher than the discount rate. However, if the NPV is less than zero, then investors cannot expect to earn a rate of return equal to the discount rate, nor can they recover their invested capital, and hence, their real net worth is expected to decrease. Only projects with positive NPV are attractive to private investors. They are unlikely to pursue a project with a negative NPV unless there are strategic reasons to do so. Many of these strategic reasons can also be evaluated in terms of their net present values through the valuation of the real options made possible by the strategic project. This leads to Decision Rule 1 of the net present value criterion that holds under all circumstances.

Rule 1: Do not accept any project unless it generates a positive NPV when discounted by the opportunity cost of funds.

(b) *Budget Constraints*

Often investors cannot obtain sufficient funds to undertake all the available projects having a positive NPV. Similarly, it is the case for governments. When such a situation arises, a choice must be made among the projects to determine the subset that will maximize the NPV produced by the investment package while fitting within the budget constraint. Thus, Decision Rule 2 is:

Rule 2: Within the limit of a fixed budget, choose the subset of the available projects that maximizes the NPV.

Since a budget constraint does not require that all the money be spent, the rule will prevent

any project that has a negative present value from being undertaken. Even if not all the funds in the budget are spent, the NPV generated by the funds in the budget will be increased if a project with a negative NPV is dropped from consideration. Keeping in mind that the funds assigned by the budget allocation but are not spent will simply remain in the capital market and continue to generate a rate of return equal to the economic opportunity cost of capital.

Suppose the following set of projects describes the investment opportunities faced by an investor with a fixed budget for capital expenditures of \$4.0 million:

	<u>Project A</u>	<u>Project B</u>	<u>Project C</u>	<u>Project D</u>
PV investment costs	\$1.0 million	\$3.0 million	\$2.0 million	\$2.0 million
NPV of net benefits	+\$60,000	+\$400,000	+\$150,000	+\$225,000

With a budget constraint of \$4 million we would explore all possible combinations that fit within this constraint. Combinations BC and BD are impossible, as they cost too much. AC and AD are within the budget, but are dominated by the combination AB which has a total NPV of \$460,000. The only other feasible combination is CD, but its NPV of \$375,000 is not as high as that of AB. If the budget constraint were expanded to \$5 million, then project A should be dropped and project D undertaken in conjunction with project B. In this case, the NPV from this package of projects (D and B) is expected to be \$625,000 which is greater than the NPV of the next best alternative (B and C) of \$550,000.

Suppose that project A, instead of having an NPV of +\$60,000, had an NPV of -\$60,000. If the budget constraint were still \$4.0 million, then the best strategy would be to undertake only project B which would yield a NPV of \$400,000. In this case, \$1 million of the budget would remain in the capital market, even though it is the budget constraint which is preventing us from undertaking the potentially good projects, C and D.

(c) No Budget Constraints

In evaluating investment projects, we often come across a situation where we have to make a choice between mutually exclusive projects. It may not be possible for all projects to be

undertaken for technical reasons. For example, in building a road between two towns, there are several different qualities of road that can be built, given that only one road will be built.

The problem facing the investment analyst is to choose from among the mutually exclusive alternatives such that the project will yield the maximum net present value. This can be expressed in Decision Rule 3:

Rule 3: When there is no budget constraint but a project must be chosen from mutually exclusive alternatives, investors should always choose the alternative that generates the largest net present value.

Consider three projects, E, F and G that are mutually exclusive for technical reasons and have the following characteristics:

	<u>Project E</u>	<u>Project F</u>	<u>Project G</u>
PV investment costs	\$1.0 million	\$4.0 million	\$1.5 million
NPV of net benefits	+\$300,000	+\$700,000	+\$600,000

In this situation, all three are good potential projects that would yield a positive net present value. However, only one can be undertaken.

Project F involves the biggest expenditure; it also has the largest NPV of \$700,000. Thus, project F should be chosen. Although project G has the biggest NPV per dollar of investment, this is not relevant if the discount rate reflects the economic opportunity cost of the funds. If we undertake project F rather than G, there is an incremental gain in NPV of \$100,000 over and above the opportunity cost of the additional investment of \$2.5 million. Therefore, project F is preferred. It is worth pointing out that NPV of a project measures the value or surplus generated by a project over and above what would be gained or generated by these funds if they were not used in the project in question.

(d) *Projects with Different Lifetime*

In some situations, an investment in a facility such as a road can be carried out in a number

of mutually exclusive ways. For example, the road services could be provided by a series of projects with short lives such as gravel surface, or by ones with longer lives such as paved surface. If the return on the expansion of the facility over its lifetime is such as to be an investment opportunity that would yield a significantly positive NPV, it would not be meaningful to compare the NPV of a project that produced road services for the full duration, to the NPV of a project that produced road services for only part of the period. The same issue arises when alternative investment strategies are evaluated for power generation. It is not correct to compare the NPV of a gas turbine plant with a life of ten years to a coal generation station having a life of 30 years. In such a case, we must compare investment strategies that have approximately the same length of life. This may involve the comparison of a series of gas turbine projects followed by other types of generation which in total have the same lengths of life as the coal plant.

When projects of short lives lead to further projects which yield supra-marginal returns, the comparison of alternative projects of different lives which will provide the same services at a point in time will require us to make adjustments to our investment strategies so they span approximately the same period of time. One such form of adjustment is to consider the same project being repeated through time until the alternative investment strategies have the same lengths of life. Consider the following three types of road surfaces.

<u>Alternative Investment Projects:</u>	<u>Duration of Road</u>
A: Gravel surfaced road	3 years
B: Gravel-Tar surfaced road	5 years
C: Asphalt surface road	15 years

If we compare the NPV of these three alternatives with lives of 3, 5 and 15 years, the results could be misleading. However, a correct comparison of these projects can be made if we construct an investment strategy which consists of five gravel road projects, each one undertaken at a date in the future when the previous one is worn out. We would then compare five gravel road projects, extending fifteen years into the future with three tar surface roads and one asphalt road of fifteen-year duration. This comparison can be written

as follows:

Alternative Strategies	Duration of Road
(i) (A + A + A + A + A)	15 years (i.e., 1-3, 4-6, 7-9, 10-12, 13-15)
(ii) (B + B + B)	15 years (i.e., 1-5, 6-10, 11-15)
(iii) (C)	15 years (i.e., 1-15)

Alternatively, it might be preferable to consider investment strategies made up of a mix of different types of road surfaces through time such as:

	Duration of Road
(iv) (A + A + A + B + C)	29 years (i.e., 1-3, 4-6, 7-9, 10-14, 15-29)
(v) (A + B + B + C)	28 years (i.e., 1-3, 4-8, 9-13, 14-28)

In this situation it is a further adjustment should be made to the 29-year strategy (iv) to make it comparable to strategy (v) that is expected to last for only 28 years. This can be done by calculating the NPV of the project after dropping the benefits accruing in year 29 from the NPV calculation while at the same time multiplying the present value of its costs by the fraction PVB_{1-28}/PVB , where PVB denotes the present value of the benefits of the entire strategy, including year 29 and PVB_{1-28} is the present value of the benefits that arise in the first 28 years of the project's life. In this way the present value of the costs of the project are reduced by the same fraction as the present value of its benefits so that it will be comparable in terms of both costs and benefits to the strategy with the shorter life.

Although the NPV criterion is widely used in making investment decisions there are also alternative criteria that frequently used. Some of these alternatives has serious drawbacks compared to the NPV criterion and are therefore judged not only less reliable, but potentially misleading. When two or more criteria are used to appraise a project, there is a chance that they will point to different conclusions, and a wrong decision could be made.¹ This creates unnecessary confusion and possibly mistakes.

¹ See, e.g., Ley, E., "Cost-benefit Analysis: Evaluation Criteria (Or: "Stay away from the IRR")", paper prepared for the World Bank, (November 2007).

4.3.2 Internal Rate of Return Criterion

The internal rate of return (IRR) for a project is the discount rate (ρ) that is obtained by the solution of the following equation:

$$\sum_{j=0}^n [(B_j - C_j) / (1+\rho)^j] = 0 \quad (4.4)$$

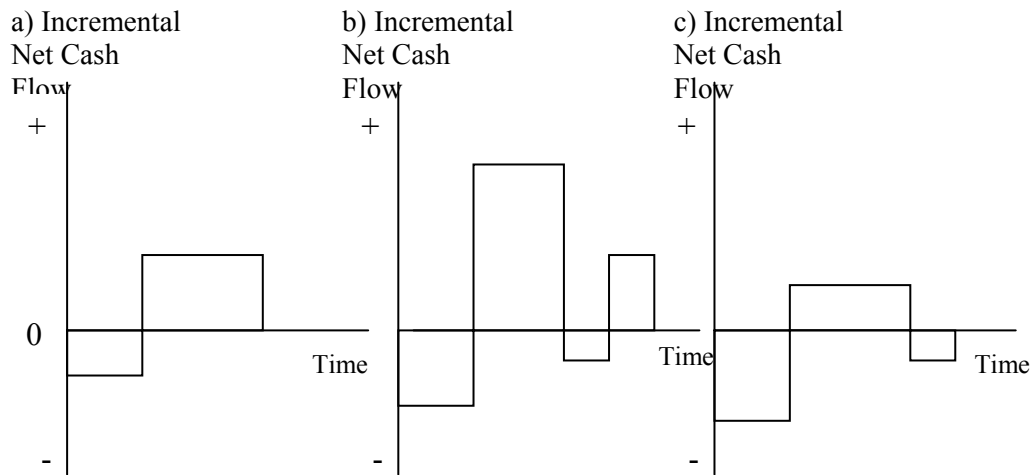
where B_j and C_j are the respective cash inflow and outflow in year t to capital. This definition is consistent with the meaning of a zero NPV that investors recover their invested capital and earn a rate of return equal to the IRR. Thus, the IRR and the NPV criteria are related in the way they are derived. To calculate the NPV the discount rate is given and used to find the present value of benefits and costs. In contrast, when finding the IRR of a project the procedure is reversed by setting the NPV of the net benefit stream at zero.

The IRR criterion has seen considerable use by both private and public sector investors as a way of describing the attractiveness of a particular project. However, it is not a reliable investment criterion as there are several problems associated with it. We shall discuss these problems in turn.

Problem No. 1: The IRR may not be unique.

The IRR is, strictly speaking, the root of a mathematical equation. The equation is based on the time profile of the incremental net cash flows like those in Figure 4.2. If the time profile crosses the horizontal axis from negative to positive only once as in Figure 4.2 (a), then the root, or IRR, will exist. However, if the time profile crosses the axis more than once as in Figure 4.2 (b) and (c), it may not be possible to determine a unique internal rate of return. Projects whose major items of equipment must be replaced from time to time will give rise to periodic negative net cash flows in the years of reinvestment. Road projects have this characteristic as major expenditures on resurfacing must be undertaken periodically for them to remain serviceable.

Figure 4.2 Time Profiles of the Incremental Net Cash Flows for Various Types of Projects



There are also cases where the termination of a project entails substantial costs. Examples of such situations are the land reclamation costs required at the closing down of a mine to meet environmental standards or the agreement to restore rented facilities to their former state. These cases are illustrated by Figure 4.2(c). These project files may yield multiple solutions for the internal rate of return; these multiple solutions, when present, face us with a problem of proper choice of the rate of return.

Let us consider the simple case of an investment of \$100 in year 0, a net benefit of \$300 in year 1, and a net cost of \$200 in year 2. The solutions for the internal rate of return are zero and 100 percent.

Even when the internal rate of return can be unambiguously calculated for each project under consideration, its use as an investment criterion poses difficulties when some of the projects in question are strict alternatives. This can come about in three ways: projects require different sizes of investment, projects have different lengths of life, and projects represent different timing for a project. In each of these three cases, the internal rate of return can lead to the incorrect choice of project.

Problem No. 2: Projects of different scale

The problem of having to choose between two or more mutually exclusive projects arises quite frequently. Examples may include two alternative buildings being considered for the same site, or a new highway that could run down two alternative rights of way. Whereas the NPV takes explicit account of the scale of the project by means of the investment that is required, the IRR ignores the differences in scale.

Let us consider a case where project A has an investment cost of \$1,000 and is expected to generate net cash flows of \$300 each year in perpetuity. Project B is strictly alternative and has an investment cost of \$5,000. It is expected to generate net cash flows of \$1,000 each year in perpetuity. The IRR for project A is 30 percent ($\rho_A = 300/1,000$) while the IRR for project B is 20 percent ($\rho_B = 1,000/5,000$). However, the NPV of project A using a 10% discount rate is equal to \$2,000 while the NPV of project B is \$5,000.

In this example, if a choice is made between projects A and B, the internal rate of return criterion would lead to us to choose project A because it has an IRR of 30 percent which is higher than 20 percent for project B. However, the fact that project B is larger enables it to produce a greater NPV even if its IRR is smaller. Thus the net present value criterion tells us to choose project B. From this illustration we see that when a choice has to be made among mutually exclusive projects with different sizes of investment, the use of the internal rate of return criterion can lead to the incorrect choice of investment projects.

Problem No. 3: Projects with different lengths of life

In this case, we have two projects C and D in which Project C calls for the planting of a species that can be harvested in five years while Project D plants a type of tree that can be harvested in ten years. The investment costs are the same for both projects at \$1,000. It is also assumed that neither of the projects can be repeated. The two projects can be analysed as follows:

	<u>Project C</u>	<u>Project D</u>
Investment Costs:	\$1,000 in Year 0	\$1,000 in Year 0
Net Benefits:	\$3,200 in Year 5	\$5,200 in Year 10
NPV Criterion @8%:	$NPV_C^0 = \$1,178$	$NPV_D^0 = \$1,409$
	$NPV_C^0 < NPV_D^0$	
IRR Criterion:	$\rho_C = 26.2\%$	$\rho_D = 17.9\%$
	$\rho_C > \rho_D$	

According to the NPV criterion, Project D is preferred. The IRR of Project D, however, is smaller than that of Project C. Thus, the IRR criterion is unreliable for project selection when alternative projects have different lengths of life.

Problem No. 4: Projects with different timing

Suppose the following two projects, E and F, are started at different times and both last for one year. Project F is started 5 years after Project E. Both projects have the investment costs of \$1,000. They are summarized as follows:

	<u>Project E</u>	<u>Project F</u>
Investment Costs:	\$1,000 in Year 0	\$1,000 in Year 5
Net Benefits:	\$1,500 in Year 1	\$1,600 in Year 6
NPV Criterion @8%:	$NPV_E^0 = \$389$	$NPV_F^0 = \$328$
	$NPV_E^0 > NPV_F^0$	
IRR Criterion:	$\rho_E = 50\%$	$\rho_F = 60\%$
	$\rho_E < \rho_F$	

Evaluating these two projects according to the net present value criterion would lead us to choose project E over project F because $NPV_E^0 > NPV_F^0$. However, we find that $\rho_E < \rho_F$ leads us to choose project F if we use the internal rate of return criterion. Again,

because projects E and F are strict alternatives, the IRR criterion can cause us to make the incorrect choice of project.

Problem No. 5: Irregularity of cash flows

In many situations the cash flows of a project may be negative in a single (investment) period but it does not occur at the beginning of the project. An example of such a situation is to look at a Build, Operate, and Transfer (BOT) arrangement from the point of view of the government. During the operating stage of this project the government is likely to receive tax benefits from the private operator. At the point when the project is turned over to the public sector the government has agreed to pay a transfer price. Such a cash flow from the government's point of view can be illustrated as project A in Table 4.2, where the transfer price at the end of the contract is \$8,000.

Table 4.2 IRR for Irregular Cash Flows

Year	0	1	2	3	4	IRR
Project A	1,000	1,200	800	3,600	-8,000	10%
Project B	1,000	1,200	800	3,600	-6,400	-2%
Project C	1,000	1,200	800	3,600	-4,800	-16%
Project D	-1,000	1,200	800	3,600	-4,800	4%
Project E	-1,325	1,200	800	3,600	-4,800	20%

Results:

Project B is obviously better than project A, yet $IRR_A > IRR_B$.

Project C is obviously better than project B, yet $IRR_B > IRR_C$.

Project D is worse than project C, yet $IRR_D > IRR_C$.

Project E is worse than project D, yet $IRR_E > IRR_D$.

This four-year project has an internal rate of return of 10%. However, suppose the negotiators for the government were successful at obtaining a lower transfer price at the end of the private sector's contract period. The situation when the contract price is reduced to \$6,400 is shown as project B. Everything else is the same as project A except for the lower transfer payment at the end of that period. In this case, the IRR falls from 10% to -2%. It is obvious that the arrangement under project B is better for the government than project A yet it has a lower IRR. If the transfer price were reduced further to \$4,800 we find that the IRR falls to a negative 16%, yet is obvious that it is a better project than either project A or B.

Now consider the situation if the government were required to pay an amount of \$1,000 at the start of the project in addition to a final transfer price of \$4,800 at the end. It is obvious that this is an inferior arrangement (project D) for the government than the previous one (project C) where no up front payment is required. However, according to the IRR criterion it is a much improved project with an IRR of now 4%.

In the final case, project E, the situation for the government is made worse by requiring an up front fee of \$1,325 in year 0, in addition to the transfer price of \$4,800 in year 4. Yet according to the IRR criteria the arrangement is more attractive with an IRR of 20%.

None of these situations are unusual. Such patterns in the case flow are common in project finance arrangements. However, we find that the IRR is a highly unreliable measure of the financial attractiveness of such arrangement when irregular cash flows are likely to exist.

4.3.3 Benefit-Cost Ratio Criterion

The benefit-cost ratio (BCR), sometimes referred to as the profitability index, is the ratio of the present value of the cash inflows (or benefits) to the present value of the cash outflows (or costs) using the opportunity cost of funds as the discount rate:

$$BCR = \frac{PV \text{ of Cash Inflows (or Benefits)}}{PV \text{ of Cash Outflows (or Costs)}}$$

Using this criterion, we would require that for a project to be acceptable the ratio (BCR) must have a value greater than 1. Also, for choices among mutually exclusive projects the rule would be to choose the alternative with the highest benefit-cost ratio.

This criterion, however, may give us an incorrect ranking of projects if the projects differ in size. Consider the following cases of mutually exclusive Projects A, B and C:

	<u>Project A</u>	<u>Project B</u>	<u>Project C</u>
PV investment costs	\$1.0 million	\$8.0 million	\$1.5 million
PV benefits	\$1.3 million	\$9.4 million	\$2.1 million
NPV of net benefits	\$0.3 million	1.4 million	\$0.6 million
BCR	1.3	1.175	1.4

In this example, if the projects were ranked according to their benefit-cost ratios we would choose project C. However, since the NPV of project C is less than the NPV of project B, the ranking of the projects should lead us to choose project B and thus, the benefit-cost ratio criterion would lead to an incorrect investment decision.

The second problem associated with the use of the benefit-cost ratio, and perhaps its most serious drawback, is that the benefit-cost ratio of a project is sensitive to the way in which costs are defined in setting out the cash flows. For example, if a good being sold is taxed at the manufacturer's level, the cash flow item for receipts could be recorded either net or gross of sales taxes.

In addition, costs can also be recorded in more than one way. Suppose that a project has the recurrent costs, the benefit-cost ratio will be altered by the way these costs are accounted for. All the costs and benefits are discounted by the cost of capital at 10 percent and expressed in dollars.

	<u>Project D</u>	<u>Project E</u>
PV investment costs	\$1,200	\$100
PV gross benefits	\$2,000	\$2,000
PV recurrent costs	\$500	\$1,800

If the recurrent costs are netted out cash inflows, Project E would be preferred to Project D according to the benefit-cost ratio criterion. This is because $BCR_D = (2,000 - 500) / 1,200 = 1.25$ and $BCR_E = (2,000 - 1,800) / 100 = 2.00$. However, if the recurrent costs are instead added to the present value of cash outflows, then Project D appears to be more attractive than

Project E because $BCR_D = 2,000/(500+1,200) = 1.18$ and $BCR_E = 2,000/(1,800+100) = 1.05$. Hence, the ranking of the two projects can be reversed depending on the treatment of recurrent costs in the calculation of the benefit-cost ratio. On the other hand, the net present value of a project is not sensitive to the way the costs are treated and therefore, it is far more reliable than the benefit-cost ratio as a criterion for project selection.

4.3.4 Pay-Out or Pay-Back Period

The pay-out or pay-back period measures the number of years it will take for the net cash flows to repay the capital investment. Project with the shortest pay-back period is preferred. It is easy to use in making investment decisions. The criterion puts a large premium on projects which have a quick pay-back and thus it has been a popular criterion in making business investment choices.² Unfortunately, it may provide the wrong results especially in the cases of investments with a long life where future net benefits are known with a considerable degree of certainty.

In its simplest form the pay-out period measures the number of years it will take for the undiscounted net cash flows to repay the investment. A more sophisticated version of this rule compares the discounted benefits over a number of years from the beginning of the project with the discounted investment costs. An arbitrary limit may be set on the maximum number of years allowed and only those investments having enough benefits to offset all investment costs within this period will be acceptable.

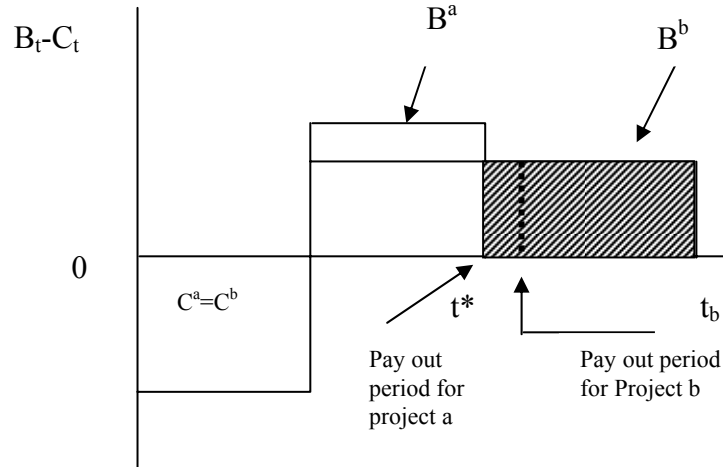
The use of the pay-back period as an investment criterion by the private sector is often a reflection of a high level of risks, especially political risk. Suppose a private venture is only expected to receive a subsidy or allowed to operate only as long as the current government is in power. In such circumstances for a private investor to go ahead with this project it is critical that its pay-back period be shorter than the expected tenure of the government.

² This criterion has similar characteristics the loan life cover ratio used by bankers. This might explain its continued use in business decision making.

The implicit assumption of the pay-out period criterion is that benefits accruing beyond the time set as the pay-out period are so uncertain that they should be neglected. It also ignores any investment costs that might occur beyond that date, such as the landscaping and replanting costs arising from the closure of a strip mine. While the future is undoubtedly more uncertain than the present, it is unrealistic to assume that beyond a certain date the net benefits are zero. This is particularly true for long term investments such as bridges, roads and dams. There is no reason to expect that all quick yielding projects are superior to long-term investments.

Let us consider the example of two projects illustrated in Figure 4.3. Both projects are assumed to have identical capital costs (i.e., $C^a = C^b$). However, the benefit profiles of the two projects are such that project A has greater benefits than project B in each period until period t^* . From period t^* to t_b , project A yields zero net benefits, but project B yields positive benefits as shown in the shaded area.

With a pay-out period of t^* years, project A will be preferred to project B because for the same costs it yields larger benefits earlier. However, in terms of net present value of the overall project, it is very likely that project B, with its greater benefits in later years will be significantly superior. In such a situation, the pay-back period criterion would give the wrong recommendation for choice among investments.

Figure 4.3 Comparison of Two Projects with Differing Lives using Pay-Out Period

4.3.5 Debt Service Coverage Ratios

The debt service coverage ratio is a key factor in determining the ability of a project to pay its operating expenses and to meet its debt servicing obligations. This is used by bankers who want to know annual debt service coverage ratio of a project on a year-to-year basis as well as a summary ratio of the loan life cover ratio.³

The annual debt service capacity ratio (ADSCR) is the ratio of the annual net cash flow of the project over the amount of debt repayment due. It is calculated on a year to year basis as follows:

$$\text{ADSCR}_t = [\text{ANCF}_t / (\text{Annual Debt Repayment}_t)]$$

where ANCF_t is annual net cash flow of the project before financing for period t , and Annual Debt Repayment $_t$ is annual interest expenses and principal repayment due in the specific period t of the loan repayment period.

³ Yescombe, E.R., *Principles of Project Finance*, London: Academic Press, (2002).

The overall project's loan life cover ratio (LLCR) is calculated as the present value of net cash flows over the present value of loan repayments from the current period t to the end period of loan repayment:

$$LLCR_t = PV(ANCF_{t \text{ to end year of debt}}) / PV(\text{Annual Debt Repayment}_{t \text{ to end year of debt}})$$

where $PV(ANCF_{t \text{ to end year of debt}})$ and $PV(\text{Annual Debt Repayment}_{t \text{ to end year of debt}})$ are the sum of the present values of annual net cash flows and annual debt repayments, respectively, over the period of the current year t to the end of loan repayment. The discount rates used are the interest rate being paid on the loan financing. The LLCR tells the banker if there is enough cash from the project to make bridge-financing in one or more specific periods when there is inadequate cash flow to service the debt.

Let us consider the example shown in Table 4.3, where an investment of \$2 million is being undertaken with a proposal for financing that includes a loan of \$1 million bearing a nominal interest rate of 15%, and a repayment period of 5 years (with an equal repayment) beginning in one year after the loan is given. The required rate of return on equity is assumed at 20%.

Table 4.3 Calculation of Annual Debt Service Coverage

Year	0	1	2	3	4	5	6	7	8	9	10
Net Cash Flow	-2,000,000	320,000	320,000	360,000	440,000	380,000	100,000	200,000	480,000	540,000	640,000
Debt Repayment	0	298,316	298,316	298,316	298,316	298,316					
ADSCR		1.07	1.07	1.21	1.47	1.27					

Table 4.3 shows the annual cash flows net of operating expenses along with the annual debt service obligations. The project is not attractive to the banker since the ADSCRs are low. It is only 1.07 in years 1 and 2 with no single years giving a debt service ratio of more than 1.47. This means that there could be a cash shortfall and an inability to pay the lenders the principal repayment and interest that is due.

The question now is how might we improve the annual debt service capacity ratios? There are fundamentally only three alternatives:

- decrease the interest rate on the loan;
- decrease the amount of debt financing; and
- increase the duration of the loan repayment.

(a) *Decrease the Interest Rate on the Loan*

If the terms of the loan can be restructured so that the annual ratios look better, maybe it will be attractive to the banker to provide financing. Table 4.4 shows the effect of obtaining a concessional interest rate, or interest rate subsidy for the loan. In this case we assume that a 1 percent interest rate can be obtained for the full five-year period that the loan is outstanding. The ADSCRs are much larger now, never becoming less than 1.55, however, such a financing subsidy might be very difficult to obtain.

Table 4.4 Decrease the Interest Rate on the loan

Year	0	1	2	3	4	5	6	7	8	9	10
Net Cash Flow	-2,000,000	320,000	320,000	360,000	440,000	380,000	100,000	200,000	480,000	540,000	640,000
Debt Repayment	0	206,040	206,040	206,040	206,040	206,040					
ADSCR		1.55	1.55	1.75	2.14	1.84					

(b) *Decrease the Amount of Debt Financing*

Table 4.5 shows the case where the amount of the loan is reduced from \$1 million to \$600 thousand. In this case we find the ADSCRs increase greatly so now they never fall below a value of 1.79. Since the amount of the annual repayment of that loan becomes smaller (equity financing is increased), the ability of the project to service the debt becomes much more certain.

Table 4.5 Decrease the amount of borrowing by increasing equity to \$1.4 million

Year	0	1	2	3	4	5	6	7	8	9	10
Net Cash Flow	-2,000,000	320,000	320,000	360,000	440,000	380,000	100,000	200,000	480,000	540,000	640,000
Debt Repayment	0	178,989	178,989	178,989	178,989	178,989					
ADSCR		1.79	1.79	2.01	2.46	2.12					

(c) *Increase the Duration of the Loan Repayment*

Table 4.6 shows the case of increasing the duration of the loan from 5 to 10 years. If a financial institution is available to extend a loan for such a long period, we find that the annual debt service obligations fall greatly. The result is that except for years 6 and 7 the annual debt service obligation never falls below 1.61. In years 6 and 7 the annual debt service coverage ratios are projected to be only 0.50 and 1.00, respectively. This is due to a projected fall in the net cash flows that might arise because the need to make reinvestments or heavy maintenance expenditures in those years.

Table 4.6 Increase the duration of loan repayment

Year	0	1	2	3	4	5	6	7	8	9	10
Net Cash Flow	-2,000,000	320,000	320,000	360,000	440,000	380,000	100,000	200,000	480,000	540,000	640,000
Debt Repayment	0	199,252	199,252	199,252	199,252	199,252	199,252	199,252	199,252	199,252	199,252
ADSCR		1.61	1.61	1.81	2.21	1.91	0.50	1.00	2.41	2.71	3.21

The question now is whether the project has sufficiently strong net cash flows in the years following years 6 and 7 to warrant the financial institution providing the project bridge financing for these two years. This additional new loan would be repaid from the surplus net cash flows in later years. To answer the question, the LLCR is the appropriate criteria to determine if the project should qualify for bridge financing. The present value of the net cash flows remaining until the end of the debt repayment period, discounted at the loan interest rate, is divided by the present value of the debt repayments for the remaining duration of the

loan. It is also discounted at the loan interest rate. These estimations are presented in Table 4.7.

Table 4.7 Is Bridge Financing an option?

Year	0	1	2	3	4	5	6	7	8	9	10
Net Cash Flow	-2,000,000	320,000	320,000	360,000	440,000	380,000	100,000	200,000	480,000	540,000	640,000
Debt Repayment	0	199,252	199,252	199,252	199,252	199,252	199,252	199,252	199,252	199,252	199,252
ADSCR		1.61	1.61	1.81	2.21	1.91	0.50	1.00	2.41	2.71	3.21
NPV of NCF		2,052,134	1,991,954	1,922,747	1,797,159	1,560,733	1,357,843	1,446,519	1,433,497	1,096,522	640,000
PV of Debt Repayments		1,150,000	1,093,360	1,028,224	953,318	867,176	768,112	654,189	523,178	372,515	199,252
LLCR		1.78	1.82	1.87	1.89	1.80	1.77	2.21	2.74	2.94	3.21

We find that the LLCRs for years 6 and 7 are 1.77 and 2.21, respectively. This indicates that there is likely to be more than adequate net cash flows from the project to safely repay the bridge financing that is needed to cover the likely shortfalls in cash during years 6 and 7.

If for some reason the banks were not comfortable providing the bridge financing needed to cover the cash flow shortfalls during year 6 and 7, they might instead require the firm to build up a debt service reserve account during the first five years of the loan's life from the cash that is over and above the requirements for servicing the debt. Alternatively, the banker may require the debt service reserve account to be immediately financed out of the proceeds of the loan and equity financing. This debt service reserve account would be invested in short-term liquid assets that could be drawn down to meet the financing requirements during years 6 and 7.

It is sometimes the case that the financial institutions servicing the loan will stipulate that if the annual debt service capacity ratio ever falls below a certain benchmark, say 1.8, then it must stop paying dividends to the owners of the equity, until a certain size of sinking fund is

created, or a certain amount of the loan is repaid. In this way the lenders are protected from what might become an even more precarious situation in the future.

The actual benchmark requirements for the ADSCRs and the overall project's LLCRs will depend on the business and financial risk associated with a particular sector and the specific enterprise. The sensitivity of the net cash flows from the project to movements in the economy's business cycle will be an important determinant of what are the adequate ratios for any specific project. The existence of creditable government guarantees for the repayment of interest and principal will also serve to lower the benchmark values of the debt service coverage ratios for a project.

4.3.6 Cost Effectiveness Analysis⁴

This is an appraisal technique primarily used in social projects and programs, and sometimes in infrastructure projects, where it is difficult to quantify benefits in monetary terms. For instance, when there are two or more alternative approaches to improving the nutrition levels among children in a community, the selection criterion could simply be to select the alternative, which has the least cost. Similarly, when there are two alternatives to provide irrigation facilities to farmers in a certain region, say a canal system and a tube well network, and they cover the same area and provide the same volume of water in a year. The benefits in such cases are treated as identical and, therefore, it is not necessary to quantify them or to place a monetary value on them if the problem is to select the project that will produce these benefits at the lowest possible cost.

This approach is also useful for choosing among different technologies for providing the same services, for example, when there are two alternative technologies related to supply of drinking water or generation of electricity. When the same quantity and quality of water per annum can be delivered using pipes of different diameters and the smaller pipe involves

⁴ See Curry, S. and Weiss, J., *Project Analysis in Developing Countries*, St. Martins Press, (1993) and Ginttinger J. P., *Economic Analysis of Agricultural Projects*, John Hopkins University Press, (1994) for discussion of Cost Effectiveness Analysis.

greater pumping costs but has lower capital costs, a cost effectiveness analysis may be used for making a choice. Similarly, when there are two alternative ways to generate electricity, one with lower investment cost but higher operating expenses (single cycle versus combined cycle technologies). Again, if the decision has been made to provide this service, there is no need to calculate the benefit in monetary terms. The cost effectiveness analysis may be used in all such cases for selecting the best project or the best technology.

If the amount of benefits of the alternative projects generate differ, and if the benefits cannot be measured in monetary terms but can be physically quantified, a pure cost-effectiveness of a project can be calculated by dividing the present value of total costs of the project by the present value of a non-monetary quantitative measure of the benefits it generates. The ratio is an estimate of the amount of costs incurred to achieve a unit of the benefit from a program. For example, in a health project, what is the amount of costs expressed in dollars incurred in order to save a person's life? Presumably, there are alternative ways to save a life and what are their costs? The analysis does not evaluate benefits in monetized terms but is an attempt to find the least-cost option to achieve a desired quantitative outcome.

In applying the cost effectiveness approach, the present values of costs have to be computed. While using the cost effectiveness analysis, it is important to include all external costs such as waiting time, coping costs, enforcement costs, regulatory costs, compliance costs in the case of health care, offset by the salvage values at the end of the projects and to choose the discount rate carefully. The preferred outcome will often change with a change in the discount rate.

The pure cost-effectiveness analysis can be extended to more sophisticated and meaningful ways of measuring benefits. A quantitative measure can be made by constructing a composite index of two or more benefit categories, including quantity and quality. For example, the cost utility analysis (CUA) in healthcare use the "quality-adjusted life-years" (QALY) as a measure of benefits. The QALY measure integrates two dimensions of health improvement; one is the additional years of life (reduction in mortality), and the other is quality of life (morbidity) during these years. On the basis of the costs incurred, expressed in

dollars, the decision-maker would still choose the option with the least cost per QALY achieved by the project or the program.⁵ Cost utility analysis attempts to include some of the benefits excluded from the pure cost-effective analysis, hence moving it a step closer to a full cost benefit analysis.

One should be aware of some of the shortcomings inherent in the cost-effectiveness approach. It is a poor measure of consumers' willingness to pay principle because there is no monetary value placed on the benefits. Furthermore in the calculation of cost-effectiveness, the numerator does not take into account the scale of alternative options. Nevertheless, the cost-effectiveness ratio is still a very useful criterion for selection of alternative options when the benefits cannot be monetized.

4.4 Conclusion

This chapter has first described the concept of time value of money and the proper use of the discount rate in project appraisal. We have reviewed six important criteria used by various analysts for judging the expected performance of investment projects. While each one may have its own merit in specific circumstances, the net present value criterion is the most reliable and satisfactory one for both the financial and the economic evaluation.

To bankers or other financial lending institutions, measurements of the annual debt service coverage ratio and loan life cover ratio are the key factors for them to determine whether the project can generate enough cash from the project to meet the debt service obligations before financing of the project should be approved. We have also discussed the criterion in which the benefits of a project or a program cannot be expressed in monetary values in a meaningful way, a cost-effectiveness analysis should be carried out to assist in making welfare improving investment decisions.

⁵ See, e.g., Garber, A.M. and Phelps, C.E., "Economic Foundations of Cost-effectiveness Analysis", *Journal of Health Economics*, 16, (1997).

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 5:**

*SCALE, TIMING, LENGTH AND INTER-DEPENDENCIES
IN PROJECT SELECTION*

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ABSTRACT

It is generally agreed that a project's net present value (NPV) is the most important criterion for the financial and the economic evaluation of a project from either the owner's or economic perspective.. The NPV criterion requires that a project analyst recommend only projects with positive NPV. The next step is to endeavor to maximize the NPV. The reason for trying to maximize the NPV is to extract as much value from the project as possible. Ideally, we should strive to maximize the NPV of incremental net cash flows or net economic benefits. Of course, optimization cannot be pursued blindly; there may be repercussions for other stakeholders that need to be considered in the final decision making. There are other important considerations project analysts often encounter. These considerations include changes in project parameters like the scale of investment, the date of initiation of a project, the length of project life or interdependencies of project components. Each of them is addressed in this chapter by using the criterion of a project's net present value. This chapter explains how project analysts use the criterion of a project's net present value to make such decisions.

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CHAPTER 5

SCALE, TIMING, LENGTH AND INTER-DEPENDENCIES IN PROJECT SELECTION

5.1 Introduction

In the previous chapter, we have concluded that a project's net present value (NPV) is the most important criterion for the financial and the economic evaluation. The NPV criterion requires that a project analyst recommend only projects with positive NPV. The next step is to endeavor to maximize the NPV. The reason for trying to maximize the NPV is to extract as much value from the project as possible. Ideally, we should strive to maximize the NPV of incremental net cash flows or net economic benefits. Of course, optimization cannot be pursued blindly; there may be repercussions for other stakeholders that need to be considered in the final decision making.

There are other important considerations project analysts often encounter. These considerations include changes in project parameters like the scale of investment, the date of initiation of a project, the length of project life or interdependencies of project components. Each of them is addressed in this chapter by using the criterion of a project's net present value.

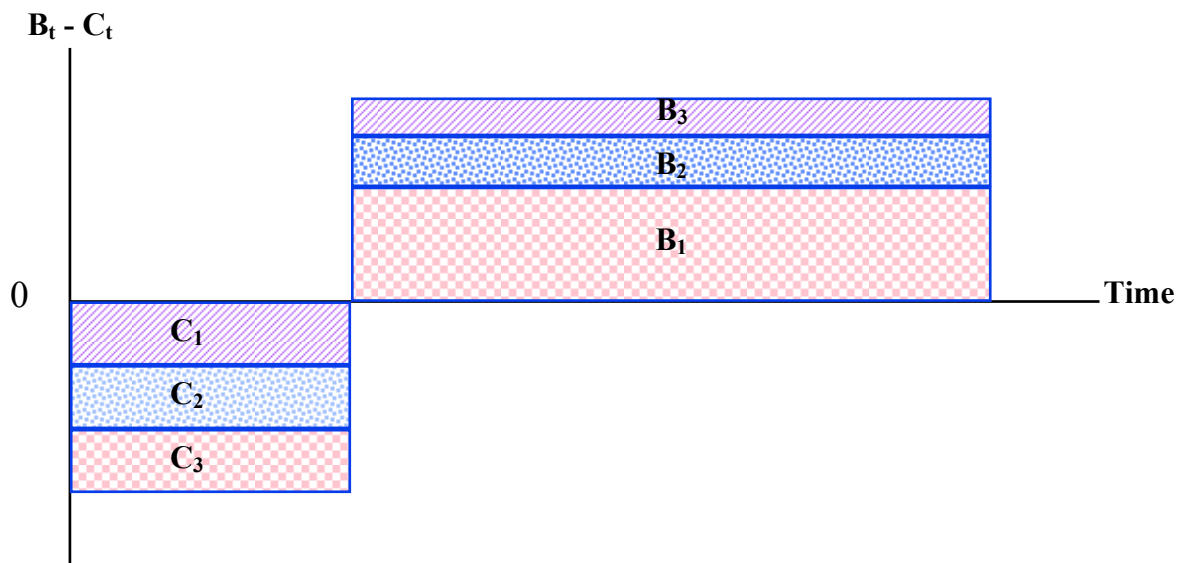
5.2 Determination of Scale in Project Selection

Projects are rarely, if ever, constrained by technological factors to a unique capacity or scale. Thus one of the most important decisions to be made in the design of a project is the selection of the scale at which a facility should be built. Far too often the scale selection has been treated as if it were a purely technical decision, neglecting its financial or economic aspects. When financial or economic considerations have been neglected at the design stage, the scale to which the project is built is not likely to be the one that would maximize the

NPV. Thus, in addition to technological factors the size of the market, the availability of project inputs, the quality of manpower, etc. will also have a role to play.

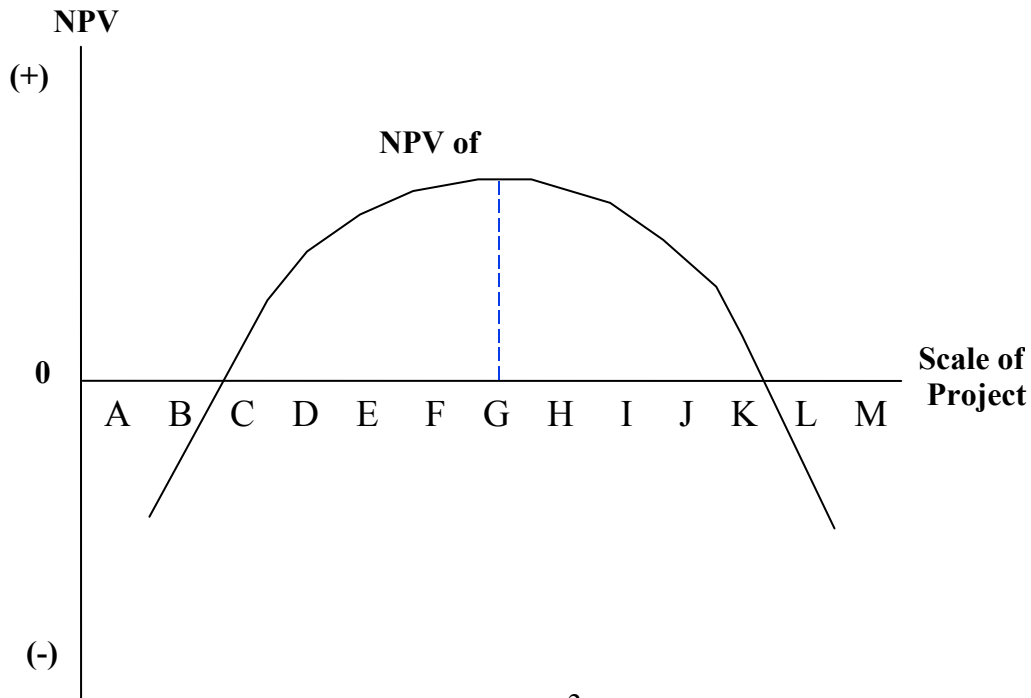
The most important principle for selection of the best scale of a project (e.g., height of an irrigation dam or size of a factory) is to treat each incremental change in its size as a project in itself. An increase in the scale of a project will require additional expenditures and will likely generate additional expected benefits over and above those that would have been produced by the project at its previous size. Using the present value of the incremental benefits and the present value of the incremental costs, the change in net present value, stemming from changing scales of the project, can be derived. In Figure 5.1 the cash flow profiles of a project are shown for three alternative scales. C_1 and B_1 denote the expected costs and benefits if the project is built at the smallest scale relevant for this evaluation. If the project is built at one size larger it will require additional expenditure of C_2 . Therefore, the total investment cost of the project at its expanded scale is $C_1 + C_2$. It is also anticipated that the benefits of the project will be increased by an amount of B_2 , implying that the total benefits from this scale of investment will now equal $B_1 + B_2$. A similar relationship holds for the largest scale of the project. In this case, additional expenditures of C_3 are required and extra benefits of B_3 are expected. Total investment costs for this scale equal $(C_1 + C_2 + C_3)$ and total benefits are $(B_1 + B_2 + B_3)$.

Figure 5.1 Net Benefit Profiles for Alternative Scales of a Facility



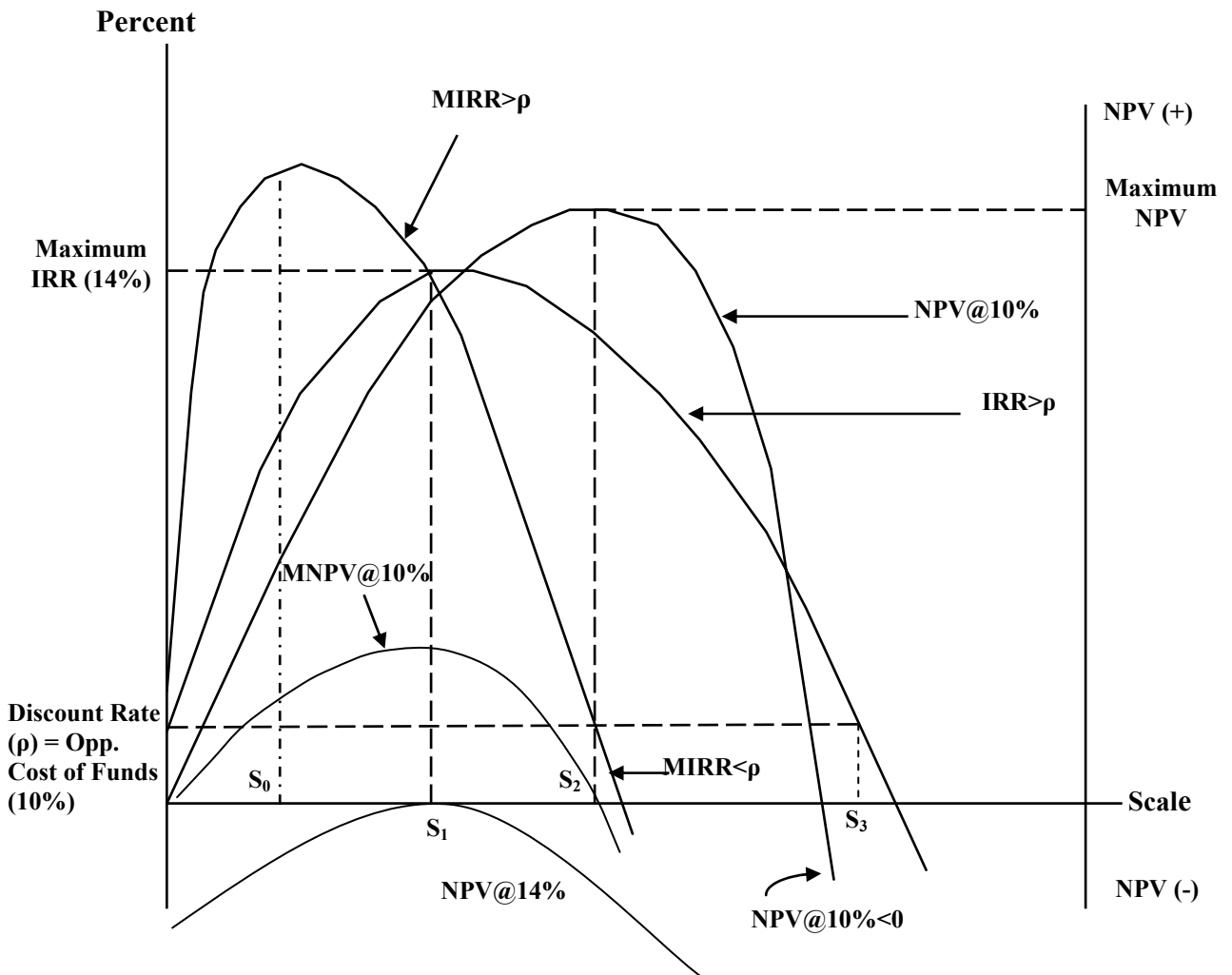
Our goal is to choose the scale that has the largest NPV. If the present value of $(B_1 - C_1)$ is positive, then it is a viable project. Next, we need to determine whether the present value of $(B_2 - C_2)$ is positive. If incremental NPV is positive, then this project at scale 2 is preferable to scale 1. This procedure is repeated until a scale is reached where the NPV of the incremental benefits and costs associated with a change in scale is negative. This incremental net present value approach helps us to choose a scale that has maximum NPV for the entire investment. The NPV is the maximum because the incremental NPV for any addition to the scale of the project would be negative. If the initial scale of the project had a negative NPV, but all the subsequent incremental net present values for changes of scale were positive, it still would be possible for the overall project to have a negative NPV. Therefore, in order to pick the optimum scale for a project, first we must make sure that the NPV of the overall project is positive and then the NPV of the last addition to the investment to increase project's scale must also be non-negative. This is illustrated in Figure 5.2 where all project sizes between scale C and scale M yield a positive NPV. However, the NPV of the entire investment is maximized at scale H. After scale H, the incremental NPV of any expansion of the facility becomes negative. Therefore, the optimum scale for the project is H, even though the NPV for the entire project is still positive until scale M.

Figure 5.2 Relationship between NPV and Scale



The optimum scale of a project can also be determined by the use of the internal rate of return (IRR), assuming that each successive increment of investment has a unique IRR. If this condition is met, then the optimum scale for the facility will be the one at which the IRR for the incremental benefits and costs equal to the discount rate used to calculate the net present value of the project. This internal rate of return for the incremental investment required to change the scale of the project will be called marginal internal rate of return (MIRR) for a given scale of facility. The relationships between the IRR, the MIRR, and the NPV of a project are shown in Figure 5.3.

Figure 5.3 Relationships between MIRR, IRR, and the NPV



From Figure 5.3 we can observe that in a typical project, the MIRR from incremental investments will initially rise as the scale is increased, but will soon begin to fall with further expansions. This path of the MIRR will also cause the IRR to rise for the initial ranges of scale and then to fall. At some point the IRR and the MIRR must be equal and then change their relationship to each other. Prior to S_1 in Figure 5.3 the MIRR of the project is greater than the IRR: here expansions of scale will cause the overall IRR of the project to rise. At scales beyond S_1 , MIRR is less than IRR: in this range, expansions of scale will cause the overall IRR to fall.

The scale where the $IRR=MIRR$ is always the scale at which the IRR is maximized. However, it is important to note that this is not the scale at which the net present value of the project is likely to be maximized. The NPV of a project obviously depends on the discount rate. Only when the relevant discount rate is precisely equal to the maximum IRR will S_1 be the optimal scale. If the relevant discount rate is lower, it pays to expand the project's scale up to the point where MIRR is equal to the discount rate. As shown for the case when the discount rate is 10 percent, this scale yields the maximum net present value at a scale of S_2 in Figure 5.3.

To illustrate this procedure for the determination of the optimal scale of a project, let us consider the construction of an irrigation dam which could be built at different heights. Because of the availability of water we would expect that expansions of the scale of the dam would reduce the overall level of utilization of the facilities when measured as a proportion of its total potential capacity. The information is provided in Table 5-1.

Table 5.1
Determination of Optimum Scale of Irrigation Dam

Time	0	1	2	3	4	5	...			
Scales	Costs	Benefits							NPV	IRR
S ₀	-3,000	250	250	250	250	250	...	-500	0.083	
S ₁	-4,000	390	390	390	390	390	...	-100	0.098	
S ₂	-5,000	540	540	540	540	540	...	400	0.108	
S ₃	-6,000	670	670	670	670	670	...	700	0.112	
S ₄	-7,000	775	775	775	775	775	...	750	0.111	
S ₅	-8,000	865	865	865	865	865	...	650	0.108	
Time	0	1	2	3	4	5	...			
Changes in Scales	Costs	Incremental Benefits							Change in NPV	MIRR
S ₀	-3,000	250	250	250	250	250	...	-500	0.083	
S ₁ - S ₀	-1,000	140	140	140	140	140	...	400	0.140	
S ₂ - S ₁	-1,000	150	150	150	150	150	...	500	0.150	
S ₃ - S ₂	-1,000	130	130	130	130	130	...	300	0.130	
S ₄ - S ₃	-1,000	105	105	105	105	105	...	50	0.105	
S ₅ - S ₄	-1,000	90	90	90	90	90	...	-100	0.090	

Notes: Discount rate (opportunity cost of funds) = 10%.

The depreciation rate of the dam is assumed at zero.

In this example we can calculate the Δ NPV for each scale of the dam from S₀ to S₅. Thus, the Δ NPV for S₀ is -500; for S₁-S₀ it is 400; for S₂-S₁ 500; for S₃-S₂ 300; for S₄-S₃ it is 50; and for S₅-S₄ it is -100.¹ If we use the above rule for determining the optimum scale, we would choose scale S₄ because beyond this point additions to scale add negatively to the overall NPV of the project. At scale S₄ we find that the net present value of the project is +750.0. At a scale of S₃ it is +700; and at S₅ it is +650. Therefore, net present value is maximized at S₄. If the project is expanded beyond scale 4 we find that the net present value begins to fall even though at a scale of S₅ the IRR of the entire project is still 0.108 (which is greater than the discount rate of 0.10). However, the MIRR is only 0.09, placing the marginal return from the last addition to scale below the discount rate.

¹ For perpetuity, the internal rate of return can be calculated as the ratio of annual income to initial investment.

5.3 Timing of Investments

One of the most important decisions to be made in the process of project preparation and implementation is the determination of the appropriate time for the project to start. This decision becomes particularly difficult for large indivisible projects such as infrastructure investments in roads, water systems and electric generation facilities. If these projects are built too soon, a large amount of idle capacity will exist. In such cases the foregone return (that would have been realized if these funds had been invested elsewhere) might be larger in value than the benefits gained in the first few years of the project's life. On the other hand, if a project is delayed too long, then shortages of goods or services will persist and the output foregone will be greater than the alternative yield of the funds involved.

Whenever the project is undertaken too early or too late, its NPV will be lower than what it could have been if it had been developed at the right time. The NPV of such projects may still be positive but it will not be at its maximum.

The determination of the correct timing of investment projects will be a function of how future benefits and costs are anticipated to move in relation to their present values. The situations where timing of investment projects becomes an important issue can be classified into four different cases. They are described as follows:

- a) The benefits of the project are a continuously rising function of calendar time, but investment costs are independent of calendar time.
- b) The benefits and investment costs of the project are rising with calendar time.
- c) The benefits are rising and then declining with calendar time while the investment costs are a function of calendar time.
- d) The benefits and investment do not change systematically with calendar time.

Case A: Potential Benefits are a Rising Function of Calendar Time

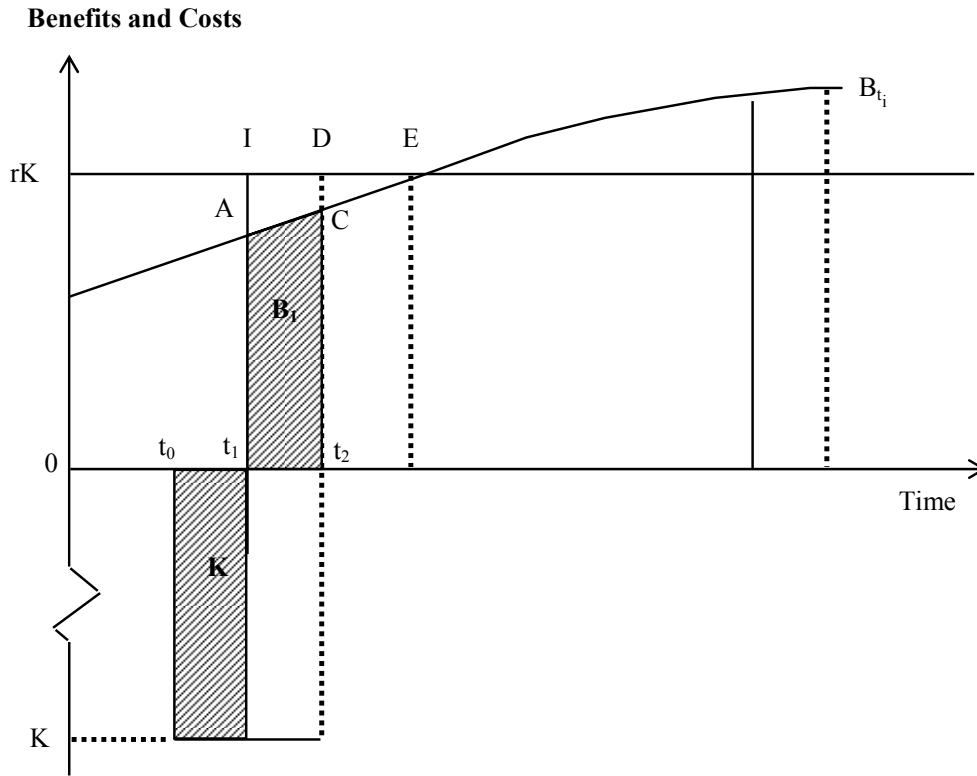
This is the case in which the benefits net of operating costs are continuously rising through

time and costs do not depend on calendar time. For example, the benefits of a road improvement rise because of the growth in demand for transportation between two or more places. It can thus be expected that as population and income grow, the demand for the road will also increase through time.

If the project's investment period ends in period t we assume its net benefit stream will start the year after construction, and will rise continuously thereafter. This potential benefit stream can be illustrated by the curve $B(t)$ in Figure 5.4. If construction were postponed from t_1 to t_2 , lost benefits amount to B_1 , but the same capital in alternative uses yields rK , where K denotes the initial capital expenditure and r denotes the opportunity cost of capital for one period. Postponing construction from t_1 to t_2 thus yields a net gain of AIDC. Similarly, postponing construction from t_2 to t_3 yields a net benefit of CDE.

In this situation the criterion to ensure that investments are undertaken at the correct time is quite straightforward. If the present value of the benefits that are lost by postponing the start of the project from time period t to $t+1$ is less than the opportunity cost of capital multiplied by the present value of capital costs as of period t , then the project should be postponed because the funds would earn more in the capital market than if they were used to start the project. On the other hand, if the foregone benefits are greater than the opportunity cost of the investment, then the project should proceed. In short, if $rK_t > B_{t+1}$, then postpone the project; if rK_t less than B_{t+1} , then undertake the project. Here t is the period in which the project is to begin, K_t is the present value of the investment costs of the project as of period t , and B_{t+1} is the present value of the benefits lost by postponing the project one period from t to t_1 .

**Figure 5.4 Timing of Projects:
Benefits are Rising but Investment Cost are Independent of Calendar Time**

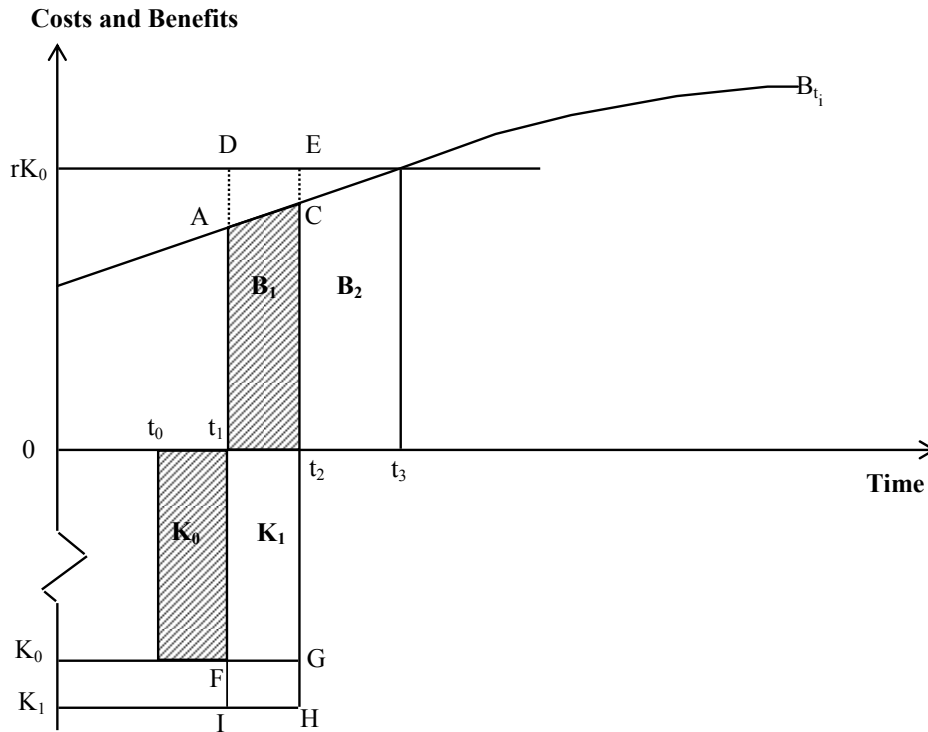


Rules: $rK_t > B_{t+1} \Rightarrow$ Postpone
 $rK_t < B_{t+1} \Rightarrow$ Start

Case B: Both Investment Costs and Benefits are a Function of Calendar Time

In this case, as illustrated in Figure 5.5, the investment costs and benefits of a project will grow continuously with calendar time. Suppose the capital cost is K_0 when the project is started in period t_0 and the costs will become K_1 if it is started in period t_1 . The change in investment costs must be included in the calculations of optimum timing. When the costs of constructing a project are bigger in period 1 than in period 0, there is an additional loss caused by postponement equal $(K_1 - K_0)$, as shown by the area FGHI in Figure 5.5.

**Figure 5.5 Timing of Projects:
Both Benefits and Investment Costs are a Function of Calendar Time**



- Rules:**
- $rK_t > B_{t+1} + (K_{t+1} - K_t) \Rightarrow$ Postpone
 - $rK_t < B_{t+1} + (K_{t+1} - K_t) \Rightarrow$ Start

In case (a) when benefits are a positive function of calendar time, the decision rule for the timing of investments is to postpone if $rK_0 > B_1$, and to proceed as soon as $B_{t+1} > rK_t$. Now when the present value of the investment costs changes with the timing of the starting date, the rule is slightly modified. It becomes: if $rK_0 > [B_1 + (K_1 - K_0)]$, then postpone the project, otherwise undertake the project. The term, $(K_1 - K_0)$, represents the savings of the increase in capital costs by commencing the project in t_0 instead of t_1 . The rule shows a comparison of the area t_1DEt_2 with t_1ACt_2 plus $FGHI$. Hence, if investment costs are expected to rise in the future, it will be optimal for the project to be undertaken earlier than if investment costs remain constant over time.

Case C: Potential Benefits Rise and Decline According to Calendar Time

In the case where the potential benefits of the project are also a function of calendar time, but they are not expected to grow continuously through time, at some date in the future they are expected to decline. For example, the growth in demand for a given type of electricity generation plant in a country is expected to continue until it can be replaced by a cheaper technology. As the alternative technology becomes more easily available and cheaper, it is expected that the demand faced by the initial plant will decline through time. If the net benefits from an electricity generation plant are directly related to the volume of production it generates, we would expect that the pattern of benefits would appear similar to $B(t)$ in Figure 5.6.

If the project with present value of costs of K_0 is undertaken in period t_0 , its first year benefits will fall short of the opportunity cost of the funds shown by the area ABC. The correct point to start the project is t_1 when $rK_{t_1} < B_{t_2}$ and if the following project's NPV measured by the present value of the area under the $B(t)$ curve minus K_1 is positive:

$$NPV = -K/(1+r) + \sum_{t=2}^n [B_t/(1+r)^t]$$

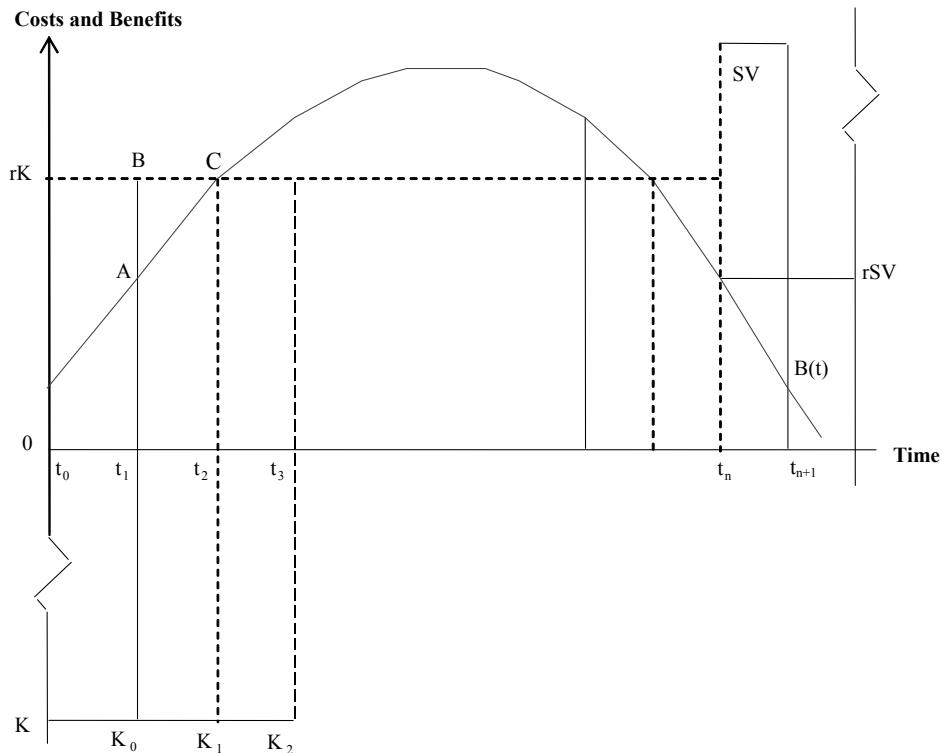
It is obviously essential that this net present value be positive in order for the project to be worthwhile.

The above formula assumes that the life of the project is infinite or that after some time its annual benefit flows fall to zero. In stead of lasting for its anticipated lifetime, the project could be abandoned at some point in time with the result that a one-time benefit is generated, equal to its scrap value, SV . In this case, it only pays to keep the project in operation so long as $B_{t_{n+1}} > rSV_{t_n} - \Delta SV_{t_{n+1}}$ so it would make sense to stay in business during t_{n+1} . If $B_{t_{n+1}} < rSV_{t_n} - \Delta SV_{t_{n+1}}$, it would make more sense to shut down operations at the end of t_n .

In practice, there are five special cases regarding scrap value and change in scrap value of a project:

- $SV > 0$ and $\Delta SV < 0$, e.g., machinery;
- $SV > 0$ but $\Delta SV > 0$, e.g., land;
- $SV < 0$ but $\Delta SV = 0$, e.g., a nuclear plant;
- $SV < 0$ but $\Delta SV > 0$, e.g., severance pay for workers; and
- $SV < 0$ and $\Delta SV < 0$, e.g., clean-up costs.

**Figure 5.6 Timing of Projects:
Potential Benefits Rise and Decline with Calendar Time**



Rules: Start if $rK_{t_i} < B_{t_{i+1}}$

Stop if $rSV_{t_n} - B_{t_{n+1}} - \Delta SV_{t_{n+1}} > 0$

Do project if: $NPV^{t_i} = \sum_{i=t_{i+1}}^{t_n} \frac{B_{t_{i+1}}}{(1+r)^{t_{i+1}}} - K_{t_i} + \frac{SV_{t_n}}{(1+r)^{t_n-t_i}} > 0$

Do not do project if: $NPV^{t_i} = \sum_{i=t_{i+1}}^{t_n} \frac{B_{t_{i+1}}}{(1+r)^{t_{i+1}}} - K_{t_i} + \frac{SV_{t_n}}{(1+r)^{t_n-t_i}} < 0$

In general, we should undertake a project if the following condition is met:

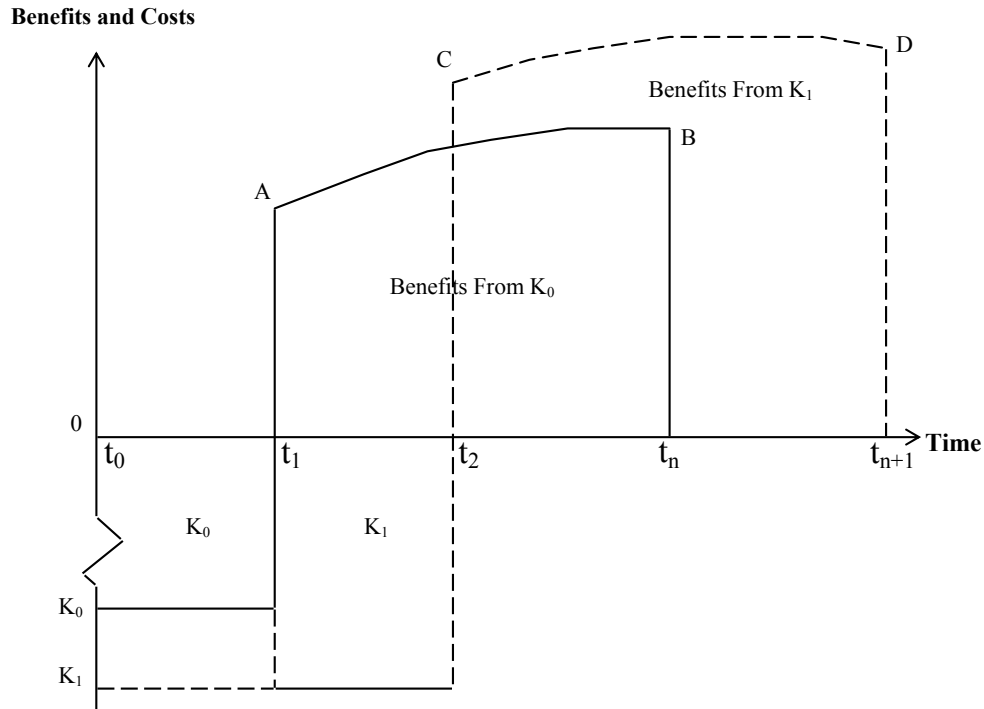
$$NPV^{t_i} = \sum_{i=t_{i+1}}^{t_n} \frac{B_{t_{i+1}}}{(1+r)^{t_{i+1}}} - K_{t_i} + \frac{SV_{t_n}}{(1+r)^{t_n-t_i}} > 0 \quad (5.1)$$

If this condition can not be met, and if $NPV^{t_i} = \sum_{i=t_{i+1}}^{t_n} \frac{B_{t_{i+1}}}{(1+r)^{t_{i+1}}} - K_{t_i} + \frac{SV_{t_n}}{(1+r)^{t_n-t_i}} < 0$, then we should not undertake the project.

Case D: Both Costs and benefits do not change systematically with calendar time

This is perhaps the most common situation where there is no systematic movement in either costs or benefits with respect to calendar time. As illustrated in Figure 5.7, if a project is undertaken in period t_0 its profile begins with investment costs of K_0 followed by a stream of benefits shown as the area t_1ABt_n . Alternatively, if it is postponed one period investment costs will be K_1 and benefits will be t_2CDt_{n+1} . In this case the optimal date to start the project is determined by estimating the net present value of the project in each instance and choosing the time to start the project which yields the greatest net present value.

**Figure 5.7 Timing of Projects:
Both Benefits and Costs do not Change Systematically with Calendar Time**



It is important to note that in determining the timing of the project, the date to which the net present values are calculated must be the same for all cases even though the period in which the projects are to be initiated varies.

5.4 Adjusting for Different Lengths of Life

When there is no budget constraint and when a choice must be made between two or more mutually exclusive projects, then investors seeking to maximize net worth should select the project with the highest NPV. If the mutually exclusive projects are expected to have continuous high returns over time then it is necessary to consider the length of life of the two or more projects. The reason for wanting to ensure that mutually exclusive projects are compared over the same span of time is to give them the same opportunity to accumulate value over time. One way to think about the NPV is as an economic rent that is earned by a

fixed factor of production. In the case of two mutually exclusive projects, for example, the fixed factor could be the building site, a right-of-way, or a license. That fixed factor should have the same amount of time to generate economic rents regardless of which project is chosen. What is required is a reasonable method of equalizing lengths of life that can be applied. This is elaborated with the help of the following two illustrations.

Illustration 1

Consider two mutually exclusive projects with the same scale of investment, a three-year project A and a four-year project B, that have the net cash flows as shown in Table 5.2. All the net cash flows are expressed in thousands of dollars and the cost of capital is 10%.

Table 5.2 Net Cash Flows for Projects with Different Length of Life

Time Period	t₀	t₁	t₂	t₃	NPV@10%
Net Cash Flows of Project A	-10,000	6,000	6,000		410
Net Cash Flows of Project B	-10,000	4,000	4,000	4,750	500

If we were to overlook the differences in the lengths of life, then we would select project B because it has the higher NPV. To do so, however, would run the risk of rejecting the potentially better project A with the shorter life.

One approach to this problem is to determine whether we might be able to repeat the projects a number of times (not necessarily the same number of times for each project) in order to equalize their lives. To qualify for this approach, both projects must be supra-marginal (i.e., have positive NPVs) and should be repeatable at least a finite number of times.

Assume that the two projects, A and B, above meet these requirements. If we were to repeat project A three times and project B twice, then both projects would have a total operating life of 6 years, as shown in Table 5.3.

Table 5.3 Net Present Value for Repeating Projects

Time	t_0	t_1	t_2	t_3	t_4	t_5	t_6
Project A's NPV for each repeat	410	–	410	–	410	–	410
Project B's NPV for each repeat	500	–	–	500	–	–	500

In year t_6 both projects can start up again, but there is no need to repeat this procedure. The construction of the repeated projects is initiated so as to maintain a level of service. For example, construction for the second project B begins in year t_3 so that it is ready to begin operations when the first project B stops providing service. Given the equal lengths of life for the repeated projects, they can now be compared on the basis of the net present value:

$$\text{NPV of Project A's repeats} = 410 + \frac{410}{(1.1)^2} + \frac{410}{(1.1)^4} = 1,029$$

$$\text{NPV of Project B's repeats} = 500 + \frac{500}{(1.1)^3} = 876$$

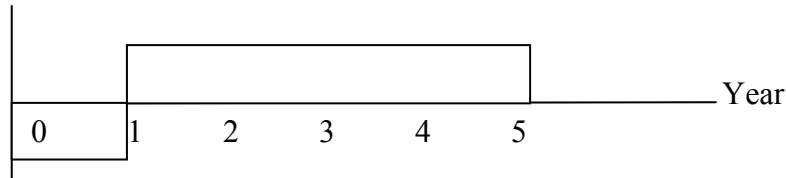
Given an equal opportunity to earn economic rents, project A has a higher overall NPV and should be considered the more attractive project.

Illustration 2

This example refers to the case when a choice is to be made between mutually exclusive projects representing different types of technology with different lengths of life.

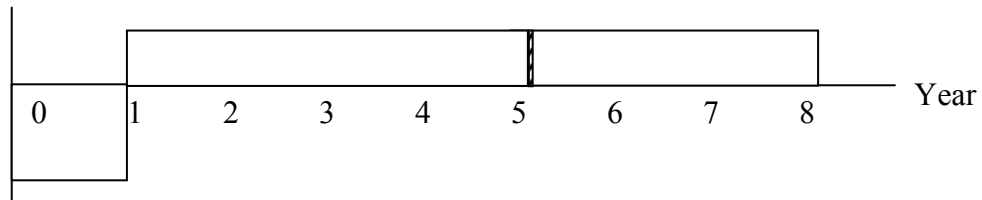
Project I (Technology 1)

$B_t - C_t$



Project II (Technology 2)

$B_t - C_t$



How can we know which technology to choose using the NPV criterion? Suppose that the present value of the costs of project I [$PV_0(C_0^I)$] is \$100 and the present value of its benefits [$PV_0(B_{1-5}^I)$] is \$122. Similarly, the present value of the costs of Project II [$PV_0(C_0^{II})$] is \$200, and of its benefits [$PV_0(B_{1-8}^{II})$] is \$225. If we compare the NPVs of the two projects, it would appear that project II is preferred to project I, because the NPV of project II is \$25, whereas that of project I is only \$22.

However, since these two projects represent two different types of technology with different lengths of life, the NPV of project II is biased upward.

In order to make a correct judgment, we need to make them comparable by either adjusting the lengths of life or calculating annualization of net benefits. The first way could be to adjust project II to make it comparable to project I. The benefits for only the first five years of project II should be included, and its costs should be reduced by the ratio of the present value of benefits from year 1-5 to year 1-8. This is expressed as follows:

$$NPV_0^I = PV_0(B_{1-5}^I)$$

$$NPV_0^{II Adj} = PV_0(B_{1-5}^{II}) - PV_0(C_0^{II}) \left(\frac{PV_0(B_{1-5}^{II})}{PV_0(B_{1-8}^{II})} \right)$$

Plugging in the values of costs and benefits of the two projects in our example, we have:

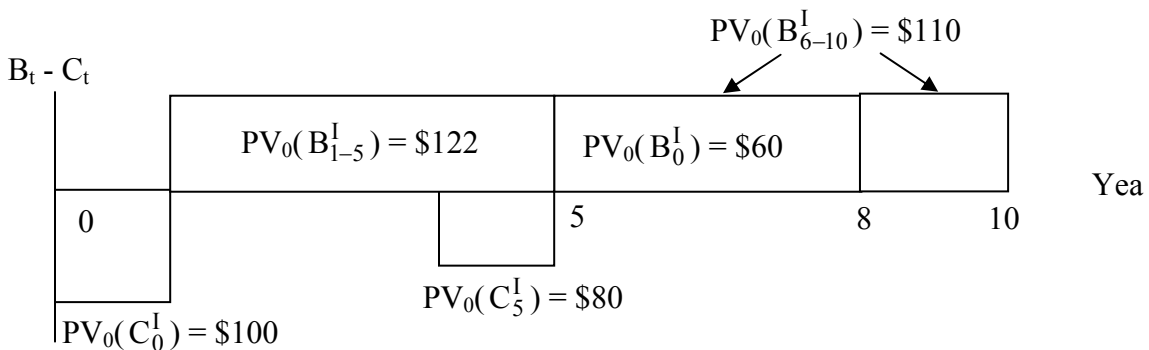
$$PV_0(B_{1-8}^{II}) = \$225, PV_0(C_0^{II}) = \$200, PV_0(B_{1-5}^{II}) = \$180.$$

Hence, the $NPV_0^I = \$122 - \$100 = \$22$, and

$$\text{the } NPV_0^{II Adj} = \$180 - \$200(180/225) = \$180 - \$160 = \$20.$$

After the adjustment, the NPV of project I is greater than that of project II which means that project I is better.

The second way to make the two projects comparable would be to adjust the length of project I. We need to calculate the NPVs of project I (adjusted) and project II. We will adjust the NPV of project I by doubling its length of life. Then the benefits of years 6-8 are added to the benefits of years 1-5. The costs are increased by the value of the costs to lengthen the project to year 8, which is the present value of the costs in year 5, reduced by the ratio of the benefits of years 6-8 to the benefits of years 6-10.



This adjustment can be expressed as follows:

$$NPV_0^{IAdj} = PV_0(B_{1-5}^I) - PV_0(C_0^I) + PV_0(B_{6-8}^I) - PV_0(C_5^I) \left(\frac{PV_0(B_{6-8}^I)}{PV_0(B_{6-10}^I)} \right)$$

Plugging in the present values of costs and benefits of the two projects in our example, we have:

$$\text{the } NPV_0^{IAdj} = \$122 - \$100 + \$60 - \$80(60/110) = \$38.36, \text{ and}$$

$$\text{the } NPV_0^{II} = \$225 - \$200 = \$25.$$

Using this method, we still have the NPV of project I greater than that of project II. Therefore, project I is preferred to project II.

The third way is to compare annualization of the net benefits of two projects. For project I, the present value of net benefits is \$22 over a 5-year period. The annualized value of the benefits can be calculated as follows:²

$$\text{Annualized Value}^I = [\$22 \cdot 0.10] / [1 - (1 + 0.10)^{-5}] = \$5.80$$

For project II, the present value of net benefits is \$25 over a 8-year period. The annualized value of the benefits is:

$$\text{Annualized Value}^{II} = [\$25 \cdot 0.10] / [1 - (1 + 0.10)^{-8}] = \$4.69$$

Again, the higher present value of the net benefits for project II than project I is due to a longer time horizon. When they are normalized in time period, it is shown that project I is in fact preferred.

5.5 Projects with Interdependent and Separable Components

Often an investment program will contain several interrelated investments within a single project. It has sometimes been suggested that in such integrated projects it is correct to evaluate the project as a whole and to bypass the examination of each of the sub-

² European Commission, *Impact Assessment Guidelines*, (June 15, 2005), and *Annexes to Impact*

components. This argument is generally not correct. The analyst should attempt to break the project down into its various components and examine the incremental costs and benefits associated with each of the components to determine whether it increases or decreases the NPV of the project.

Suppose the task is to appraise a project to build a large storage dam, planned to provide hydroelectric power, irrigation water, and recreational benefits. Upon first examination of this project it might appear that these three functions of the dam are complementary, so that it would be best to evaluate the entire project as a package. However, this is not necessarily the case. The irrigation water might be needed at a different time of the year than the peak demand for electricity. The reservoir might be empty during the tourist season if the water were used to maximize its value in generating electricity and providing irrigation. Therefore, to maximize the NPV of the whole package, it may mean that efficiency of some of the components will be reduced. In this case the overall project might be improved if one or even two of the components were dropped from the investment package.

To appraise such an integrated investment package we should begin by evaluating each of the components as an independent project. Thus, the hydroelectric power project would be evaluated separately. The technology used in this case would be the most appropriate for this size of an electricity dam without considering its potential as a facility for either irrigation or recreational use. Similarly, the use of this water supply in an independent irrigation project or an independent recreational development should be appraised on its own merits.

Next, the projects should be evaluated as combined facilities such as an electricity-cum-irrigation project or an electricity-cum-recreational project or an irrigation-cum-recreational project. In each of these combinations the technology and operating program should be designed to maximize the net benefits from the combined facilities. Lastly, the combined electricity, irrigation and recreational project are evaluated. Again, the technology and operating plans will have to be designed to maximize the net benefits from the combined

facilities. These alternatives must now be compared to find the one that yields the maximum NPV. Frequently, the project which ends up with the greatest NPV is one containing fewer components than was initially proposed by its sponsor.

A common investment problem of the type which involves separable component projects arises when a decision is being made as to whether or not existing equipment should be replaced. When faced with this decision, there are three possible courses of action:

- (a) Keep the old asset and do not buy the new asset now;
- (b) Sell the old asset and purchase the new one; or
- (c) Keep the old asset and in addition buy the new one.

Let us denote the present value of all future benefits that could be generated by the old asset (evaluated net of operating cost) by B_o and the liquidation or scrap value of the old asset if sold as SV_o . We will express the present value of future benefits (net of operating costs) from the new asset as B_n and the present value of the investment costs for the new asset as C_n . Also, the combined benefits from the use of the old and new asset together will be denoted as B_{n+o} .

The first thing that has to be done is to appraise all of the three alternatives to determine which of them are feasible, i.e., which of the three generate positive net present values. These comparisons are as follows:

- (1) In order that alternative (a) be feasible, it is necessary that the present value of the future benefits from the old asset exceeds its liquidation value, i.e., $B_o - SV_o > 0$.
- (2) In order for alternative (b) to be feasible, it is necessary that the present value of the future benefits from the new asset be bigger than the present value of its investment costs, i.e., $B_n - C_n > 0$.
- (3) For alternative (c) to be feasible, the total benefits produced by both assets combined must be greater than the costs of the new investment plus the liquidation value of the

old asset. In this case the old asset is retained to be used along with the new asset.

This is expressed as $B_{n+o} - (C_n + SV_o) > 0$.

If each of the alternatives is feasible, then we must compare them to determine which component or combination yields the greatest NPV. To determine whether or not to replace the old asset with the new one, we inquire whether $(B_n - B_o) - (C_n - SV_o) > 0$. If this expression is less than zero, then we surely will not exchange assets, but would still be willing to retain the old asset while purchasing the new one if $(B_{n+o} - B_n) - SV_o > 0$. This condition for retaining the two assets amounts to each of them justifying itself as the marginal asset. Alternatively, if $(B_n - B_o) - (C_n - SV_o) < 0$ and $(B_{n+o} - B_o) - C_n < 0$, then we should simply continue using the old facilities without any new investment. Finally, if the conditions are $(B_n - B_o) - (C_n - SV_o) > 0$ and $(B_{n+o} - B_n) - SV_o < 0$, then we should replace the old asset with the new one.

One way to describe the comparisons that have just been made is to define $(B_{n+o} - B_o)$ as $B_{n/o}$ and $(B_{n+o} - B_n)$ as $B_{o/n}$. In this notation $B_{n/o}$ is the incremental benefit of the new asset in the presence of the old, and $B_{o/n}$ is the incremental benefit of the old asset in the presence of the new. The condition that is required for both assets to be present in the final package is that both $B_{n/o} > C_n$ and $B_{o/n} > SV_o$. This means each component must justify itself as the marginal item in the picture.

This same principle governs in all cases where one has to deal with separable components of a project. Each separable component must justify itself as a marginal or incremental part of the overall project.

The careful examination of the alternative components of a potentially integrated project is thus an important task in the preparation and appraisal phase of a project. Failure to do so may mean that potentially valuable projects are not implemented because they were evaluated as part of a larger unattractive package. On the other hand, wasteful projects might get implemented because they have been included in a larger integrated project which as a whole is worthwhile, but could be improved if the wasteful components were eliminated.

Complementarity and Substitutability among Projects

Once the door has been opened to interrelations among projects, a substantial gamut of possibilities emerges. It is instructive to examine these possibilities in detail. Denoting PVB as present value of benefits and PVC as present value of costs, we have the following cases:

$PVB_I + PVB_{II} = PVB_{I+II}$ Projects I and II are independents on the benefit side;

$PVB_I + PVB_{II} > PVB_{I+II}$ Projects I and II are substitutes on the benefit side;

$PVB_I + PVB_{II} < PVB_{I+II}$ Projects I and II are complements on the benefit side;

$PVC_I + PVC_{II} = PVC_{I+II}$ Projects I and II are independents on the cost side;

$PVC_I + PVC_{II} > PVC_{I+II}$ Projects I and II are complements on the cost side;

$PVC_I + PVC_{II} < PVC_{I+II}$ Projects I and II are substitutes on the cost side.

We will not deal with independent projects here. Examples would be a spaghetti factory in San Francisco and a highway improvement on Long Island. One has essentially nothing to do with the other. We have already dealt with a case where projects are substitutes on the benefit side. It is impossible for a multipurpose dam to generate, as a multipurpose project, the sum total one could get of the benefits of the same project (e.g., a dam), independently maximized for each separate purpose, were added together. Thus, multipurpose dams invariably entail substitution among the separate purposes.

Complementarity on the benefit side is almost easy to deal with. An automobile will not function on three wheels or without a carburetor. Hence the marginal benefit of adding the fourth wheel, or the carburetor, is enormous. A more subtle case of complementarity on the benefit side, well known in the literature of economics, is that of an apiary project together with an orchard. The presence of the orchard enhances the benefits of the apiary; the presence of the bees also enhances the value of the orchard.

Whereas the separate purposes of multipurpose dams are invariable substitutes on the benefit

side, they are practically always complements on the cost side. To build one dam to serve several purposes will almost always cost less than the sum total of the two or more costs of building (at least hypothetically) separate dams to serve each of the separate purposes.

Cases of substitutability on the cost side are a bit harder to come by, but they clearly exist. A dam project that will produce a larger lake will clearly be competitive with a highway whose natural route would cross the area to be flooded. The total costs of the two projects together will exceed the sum of the costs of the two, considered above. Similarly, a project to urbanize an area will likely compound the costs of a highway project going through that area.

Altogether, one must be alert to the possibilities of substitution and complementarity between and among projects. The underlying principle is always the same: maximize net present value. Its corollary is precisely the principle of separable components, previously stated. Each separable component must justify itself as the marginal one. This becomes a problem where issues of substitutability are involved, rarely so in cases of complementarity on both sides (benefits and costs). Perhaps the most interesting cases are those (like multipurpose dams) where complementarity on one side (in this case the cost side) has to fight with substitutability on the other.

5.6 Conclusion

Timing and scale of projects are often important consideration of project evaluation. This chapter has discussed the issues and presented some decision rules for projects according to the net present value criterion. Project analysts are also often to face an issue of choosing highly profitable mutually exclusive projects with different lengths of life. We have provided alternative approaches to either adjust the costs or benefits or annualize the benefits in making a choice between mutually exclusive projects.

In reality, an investment often contains several interrelated investment, either substitute or complementary. We have demonstrated that the concept of the net present value of the

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project's benefits and costs can provide a powerful tool for selecting project with single component or combination of components.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 6:**

**DEALING WITH UNCERTAINTY AND RISK
IN INVESTMENT APPRAISAL**

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ABSTRACT

In the financial cash flow analysis, a set of values for the project variables are selected to carry out the analysis for the base case that are projected over the life of the investment project. The values of these variables used in the analysis and the resulting outcomes from a predictive model are single values. In reality, uncertainty, which refers to variability in the value, is always present surrounding each of the future values of a project's key variables throughout the project life. In some cases especially environmental and health projects, because of lack of scientific knowledge and presence of technological innovation, it would be even more difficult to make projections. The uncertainty is further compounded as the effects of the project would be spread over a long period of time in the future. This chapter shows how to move from the deterministic world developed in the base case to a dynamic and probabilistic world in which uncertainty and risk in outcomes prevail in order that the analysis can present more objective and realistic results for decision makers. It also discusses how uncertainty and risk can be addressed and mitigated while managing the project.

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CHAPTER 6

DEALING WITH UNCERTAINTY AND RISK IN INVESTMENT APPRAISAL

6.1 Introduction

In the financial cash flow analysis, project variables such as input and output prices and their quantities have been so far based on the deterministic values in which analysts make the best projection over the life of the investment project. The values of these variables used in the analysis and the resulting outcomes from a predictive model turn out to be single values with 100% certainty of occurring. In reality, uncertainty, which refers to variability in the value of some item such as a future commodity price, is always present surrounding each of the future values of a project's key variables throughout the project life. In some cases especially environmental and health projects, because of lack of scientific knowledge and presence of technological innovation, it would be even more difficult to make projections. The uncertainty is further compounded as the effects of the project would be spread over a long period of time in the future.

This chapter shows how to move from the deterministic world developed earlier to a dynamic and probabilistic world in which uncertainty and risk in outcomes prevail in order that the analysis can present more objective and realistic results for decision makers. It also discusses how uncertainty and risk can be addressed and mitigated while managing the project. Section 6.2 explains why the risk analysis of an investment project should be considered as an integral part of the appraisal exercise. Section 6.3 defines risk for the purposes of investment appraisal while Section 6.4 discusses how one can go about identifying a project's risk variables and how the risk analysis of the project is conducted. Section 6.5 provides a conceptual framework for the potential use of contractual arrangements for shifting and mitigating project risks. Contracts provide a vehicle to redistribute risk among project participants. While contracts can create incentives to alter the behavior of participants, they will also affect the overall return of a project. Section 6.6

describes a series of risks that are often encountered when arranging for project financing and outlines a few of the contractual arrangements for mitigating and shifting these risks. Conclusions are made in the last section.

6.2 Importance of Risk Analysis in Investment Appraisal

The traditional financial cash flow analysis, similar to those presented in Chapter 3, is based on single (deterministic) values for all of the project's variables. As a result, the outcome of the financial analysis is a point-estimate of a project's net present value, internal rate of return, loan life cover ratio, and some other financial performance measures. The outputs of the economic and distributional analyses are also point estimates of the economic return and the gains and losses to the project's different stakeholders. The decision whether to accept a project should not be made only on the basis of such information, because the values for most of the project's variables are likely to change. While historical values of a particular variable are known with certainty, predicting future values is an entirely different matter. There is no guarantee that the projected values, irrespective of how they were arrived at, will actually materialize. This indicates that uncertainty or variability of key project variables will generate a largely unpredictable single-value or "certainty equivalent" outcome of the project. As such, a project that may have appeared acceptable on the basis of the deterministic analysis may be much less desirable once the variability of the results is taken into account.

In the financial cash flow analysis, we are essentially dealing with the values of cost and revenue items projected over the distant future. These values are rarely known with any degree of certainty. Each of the project variables affecting the NPV of a project is subject to a high degree of uncertainty. For example, the costs of building plants, prices of machinery, oil and other intermediate inputs, and sales of the project outputs are all subject to changes in demand and supply in their respective markets that are difficult to project even for the next year or two, let alone for the next ten or more years. Similarly, the macroeconomic variables like the rate of inflation, market exchange rate and interest rate are subject to changes in the economic conditions and the government policies that go beyond the foreseeable future for

the project analyst. These variables, however, have an impact on both the financial profitability of the project and its economic viability.

Any judgment based only on the deterministic future values of project variables and the consequential NPV and debt service ratios can be dangerous because it is almost certain they will never occur in reality. For example, estimates of time and vehicle operating cost savings resulting from improving a road can be uncertain due to unpredictability of the passenger and cargo traffic in the future that are key factors affecting the investment decision. These phenomena in effect make the pin-point, single-value, outcome of the project unpredictable. It is therefore unrealistic to rely on the deterministic values of the variables influencing a project decision. It is rather better to build the analysis based on probabilistic values of the project's input variables which, in turn, will yield expected mean values as well as probabilities which in their totality will represent the certainty equivalent estimate for achieving the project's output variables such as NPV. Moreover, because such an analysis will reveal the pattern of possible outcomes (in the shape of a probability distribution), decisions can then be formed based on individual tolerance of risk as well.

Uncertainty and risk analysis is important for a number of reasons. First, we need to reduce the likelihood of undertaking a "bad" project while not failing to accept a "good" project. It may be easy to avoid "bad" projects simply by making very conservative assumptions about the values of the key variables and then accepting only those projects that still have a positive NPV. For example, we could lower the estimates of the net cash flows from operations by increasing the capital expenditures by 100 per cent. If a project still had a positive NPV, then we would be much more inclined to believe that it may still be viable.

Second, once uncertainty is analyzed and risk is understood, the project may enter into contractual arrangements to lower the riskiness of its returns and help save potentially good projects. For example, suppose the economic NPV of a project is positive based on the deterministic analysis but there is a large degree of variability in the returns that renders the project unacceptable. It may be possible to mitigate the overall risk of the project through

contractual arrangements among stakeholders, thereby saving a potentially good project from being rejected.

Third, one of the ways of reducing uncertainty is to gather more data and information, to the extent feasible, about the key project variables in order to narrow their likely range and to determine more precisely the appropriate input probability distribution. To do this, we first need to identify those variables that are key determinants of a project's NPV through sensitivity analysis. Otherwise, we risk wasting our scarce resources by researching many variables rather than focusing on the most critical ones. Moreover, attempting to estimate probability distributions for all or many input variables rather than just those that carry most of the risk will increase the level of complexity and exaggerate the problem of correlations between risk variables when applying Monte Carlo Simulation.

6.3 Definition and Measurement of Uncertainty and Risk

Risk analysis encompasses the identification of a project's risk variables and the uncertainty they represent, the analysis of the impacts of these risk variables on the project, and the interpretation of the results. A risk variable must be uncertain in terms of the difficulty in predicting its future values as well as being significant in terms of its impact on the project outcome.¹ A good example would be the price of a major product of the project. Quite often the price of a project's output is uncertain in the future and it has direct consequences in financial viability for the investors as well as the economic well-being for the nation as a whole.

Risk may result from the nature of uncertainty encompassing a particular variable and the availability of historical data on which to base an estimate for both the range of possible outcomes and their respective probabilities. For purposes of illustration, consider the case of a tradable commodity such as sugar. Historical world prices are available so one can venture a schedule of prices and associated probabilities. Despite having this information, there is

¹ See, e.g., Savvides, S.C., "Risk Analysis in Investment Appraisal", *Project Appraisal*, Vol. 9, No. 1, (March 1994).

still uncertainty as to what prices the project will face as there is no guarantee that the future will follow the same pattern as the past. A second level of uncertainty arises when we can reasonably estimate the range of expected possible prices but we cannot attach probabilities to each value with any degree of confidence. A third level of uncertainty arises when it is difficult to find any historical data or expert judgment on which to base a forecast for either the range of possible values or their respective probabilities. Based on the above definitions, we can see that project risk variables will involve different levels of uncertainty and variability.

It is important to realize that the uncertainty of a variable or group of variables does not necessarily result in a risky outcome. For example, a road project connecting two towns may be expected to generate a net economic NPV of \$20 million under low estimates of road use, value of time and operating cost savings. On the other extreme, under high estimates of road use, value of time and operating cost savings, the project may be expected to generate an economic NPV of \$100 million. In this case, the uncertainty in the input variables has resulted in variability in the outcome but not necessarily in any risk as the project is expected to yield positive economic benefits under all expected states of nature. It is, however, more common to end up with a situation that the project with certain probability may yield negative returns or values below an acceptable threshold.

There are several measures for assessing a project's risk. We rely on two measures: the project's probability of having a negative return or not meeting a certain threshold value for a particular outcome, and the expected loss from the project. While these two measures are typically used irrespective of the point of view of the stakeholder, the actual outcome assessed may vary from one stakeholder to another. For example, the main concern of a project's owner is the increase in net wealth as reflected by the financial NPV, while a banker's concern would be the project's ability to pay its debt services, thereby focusing on probabilities of meeting targeted DSCRs. The government is primarily concerned about the probability of an overall economic benefit, or a return to certain groups in society.

6.4 Steps to Conduct Risk Analysis

Risk variables are not only uncertain in nature but also significant in terms of their impact on the project outcome. The latter can be identified from sensitivity analysis. The analysis and management of the risk impacts can be carried out using the Monte Carlo simulation technique. The steps in conducting risk analysis are described below.

6.4.1 Sensitivity Analysis

The first step in conducting risk analysis of a project is to identify the risk variables. Sensitivity analysis is typically utilized in the identification of these variables. This analysis is a means of testing how sensitive a project's outcomes (e.g., financial NPV, economic NPV, DSCRs, gains and loss to different stakeholders) are to changes in the value of one parameter at a time. It is often referred to as "what if" analysis, because it allows a financial analyst to answer questions, such as "What would happen to the NPV if variable x were to change by a certain amount or percentage?"² It should be noted that some of the input variables that have a significant impact on the financial outcome of a project may have a much smaller impact on the economic appraisal and vice versa.

The following steps are used for conducting the sensitivity analysis on the financial results of a project:

- a) Develop the deterministic financial cash flow model of a project and estimate its NPV and DSCRs as explained in Chapters 3 and 4. This is called the *base case* analysis.
- b) Conduct sensitivity analysis by altering either the values of the project input variables or the assumptions that underpin the values that were estimated. The variables can be specific to the project (such as prices, costs and quantities sold) or

² Most spreadsheet software programs allow for changes in either one or two input variables at a time. It is essential to have sensitivity analysis before conducting Monte Carlo simulation. One of the uses of sensitivity analysis is also to check whether the financial cash flow model has been correctly developed since it provides a

macroeconomic variables like the performance of the economy (e.g., the growth rate of real GDP).

- c) While holding the values of other variables constant, let the base-case value of an input variable (price for example) change by, say, 10%, and calculate the percentage change in the financial NPV and DSCRs for certain years. The resulting numbers measure the degree of sensitivity of each of the project outcomes (e.g., financial NPV and DSCRs) to change in an input variable, while holding other variables constant.

This process is repeated for each of the input variables that are expected to have some impact on the financial outcomes of the project. For those variables that cause the greatest change in the financial outcomes, one can calculate what happens to the financial NPV as values for one variable are changed over their likely range. If the NPV turns negative after only a small change in a variable, it may signal that the project is financially risky to the investors and would need to be either rejected by them or restructured in a way that can mitigate the risks before the project is initiated.

The risk variables must satisfy two criteria. First, they account for a large share of cash receipts (benefits) or cash disbursements (costs). Second, their impact on the projected results remains significant within the range of probable values. Where it is possible to narrow down the margins of uncertainty through gathering additional information or by entering into an appropriate contractual arrangement, a highly sensitive variable will not qualify to be a risk variable. For example, if appropriate remedies in the form of undertakings and guarantees are provided by a contractor to build the project, then escalations in “capital investment costs” may cease to be an active risk variable. Moreover, in some cases where a variable could have a wide range of values, but its variation may not impact much on the NPV unless it represents a considerable share of the revenues or costs. Suppose an input accounts for 1% of the project cost, having a large fluctuation will not likely to create much uncertainty in the financial results of the project. Similarly, a variable

good means to audit the model and correct mistakes.

could constitute a large proportion of revenues or costs, but it will not be a major source of risk unless it is expected to vary considerably. For example, if the tariff for the electricity received by a power producer is fixed, the price of electricity is not going to be a source of risk even though the price is a major determinant of the project's revenues.

That being said, sensitivity analysis has a number of limitations. First, although it accounts for the likely range of values for a variable, there are no probabilities attached to the values in a range. As a result, sensitivity analysis does not recognize that certain values are more likely to occur than others. Second, input variables are altered one at a time without taking into account any relationship between variables. When the selling price of a product varies, for example, it is likely to affect the quantities sold but so will revenue projections. This shortcoming can be rectified by conducting the scenario analysis on revenues rather than selling prices, or by specifying a formula link or some correlation between variables in the deterministic base case model. Third, how the results of a sensitivity analysis are viewed may depend on the risk preferences of investors or other stakeholders. That is to say, what one individual may consider unduly risky, another one who is less risk averse may consider acceptable.³ For these reasons, it is difficult to derive a general decision rule about whether to accept or reject a project based on sensitivity analysis alone.

6.4.2 Scenario Analysis

A scenario analysis simultaneously changes two or more variables to determine the joint, or combined, effect. It recognizes these interrelationships to be altered in a consistent manner at the same time. Scenarios can be based on macroeconomic factors like the performance of the economy (e.g., expansion, normal, recession), industry-specific factors like the behavior of competing firms, or project-specific factors like the possibility of a technological breakthrough.

³ It should be noted that investor risk preference affects all aspects of capital investment decisions and as such it has an impact not only in sensitivity analysis but also in scenario analysis and Monte Carlo simulation risk analysis.

General steps for conducting a scenario analysis of a project are outlined as follows:

- a) Identify the key sets of circumstances, usually based on the major sources of uncertainty, that are likely to determine the success or failure of a project. For example, scenarios are sometimes defined as worst (pessimistic) case, expected (best-guess) case, and best (optimistic) case.
- b) The values of each of the variables in the financial or economic analysis are adjusted to be consistent with each scenario.
- c) Calculate the values of different project outcomes required (such as financial NPV and economic NPV) for each scenario.

In some cases the interpretation of the results is easy. For example, if the NPV is positive even in the worst case, one can accept the project; if the NPV is negative even in the best case, then the project should be rejected. However, if the NPV is positive in the best case and negative in the worst case, then the results are more difficult to interpret, but a decision can still be made with the knowledge of the “downside” and “upside” risk potential. If the downside risk is too great, further measures may be necessary to mitigate the risk if the project is to be undertaken.

The main shortcoming of scenario analysis is its failure to take into account the probabilities associated with each scenario even though it allows for interrelationships between variables. Second, the scenarios themselves are likely to be discrete rather than continuous. This presents no problem in some cases where an event either happens or does not happen, but in others the scenarios that are defined may not fully reflect all of the possible situations that could arise. Third, it is rather difficult to determine the various scenarios that are relevant for decision making before one has first determined what the range of possible outcomes for the project is.

6.4.3 Monte Carlo Analysis

Monte Carlo analysis is a natural extension of sensitivity and scenario analysis. It uses a random sampling process to approximate the expected values and the variability inherent in the assumptions which are expressed as probability distributions for the most sensitive and uncertain parameters (risk variables). It is a computer-aided methodology through which many possible project scenarios are generated through a random selection of input values from the specified probability distributions. Monte Carlo is a scientific technique (originally devised and used in the physical sciences) through which it is possible to simulate how the project may develop in the future. It creates multiple versions of the future based on what is considered possible to happen by studying and defining the expected variability of the input parameters used in the projected financial and economic model. This is made possible by expressing the uncertainty of input variables as probability distributions and then through customized software the computer is allowed to select randomly, but in accordance to their specified probabilities, values which are inserted into the parameter table of the financial cash flow model to generate a series of possible project outcomes. This process is repeated numerous times (1,000 to 10,000) so that a number of probability distributions (and statistics) of project results are produced that also includes the variability of the project and represents the wider picture of the expected risk and return to the investors, the financiers and other stakeholders in the project. As such, the technique can also be employed to assess the potential benefit or costs of financial contracts used to mitigate some of the project's risk. Risk analysis using Monte Carlo methodology is therefore a useful tool in developing contracts to mitigate and manage project risk.

Monte Carlo analysis addresses the main concerns regarding sensitivity and scenario analyses. By identifying probability distributions for the uncertain variables, we obtain a defined distribution for each of the specified variables according to historical data or subjective judgments by professional experts in the field. The distribution tells us the expected value of the outcome as well as the probabilities of higher and lower values for the outcome. The analysis allows for the modeling of a large number of scenarios that generate a

random, and therefore methodologically objective, probability distribution of the outcome resulting from the combined effect of all the specified input probability distributions.⁴

The following steps are required to undertake a Monte Carlo risk analysis of a project:⁵

- a) Identify risk variables that not only constitute a large share of revenues or costs of the project but also uncertain in nature.
- b) Link each risk variable in the financial cash flow model of the deterministic case.
- c) Assess how likely the risk is to occur and determine whether any truncation limits are needed. Truncation allows an analyst to put a ceiling on the value of a variable.
- d) Select the probability distribution (uniform, triangular, normal, step, or discrete) and the range of values for each risk variable.⁶ The appropriate probability distribution is selected based on a historical series of values or the opinions of experts in the field.⁷
- e) Identify and manage the relationship between correlated variables to avoid inconsistent simulation results.
- f) Select the model results that the computer program is supposed to monitor and report during the simulation.
- g) Specify the desired number of simulation runs (usually 1,000 to 10,000) and then run the simulations.⁸ Each run represents a scenario where a particular value for each identified risk variable is selected according to the specified probability distribution, correlations between variables, etc.

⁴ A crucial part of any Monte Carlo exercise is the setting and handling of correlated risk variables during the simulation phase. For more on the treatment of correlated variables in Monte Carlo Simulation, please refer to Pouliquen, L.Y., "Risk Analysis in Project Appraisal", World Bank Staff Occasional Papers no.11, the John Hopkins University Press, (1970), and Savvides, S.C., "Risk Analysis in Investment Appraisal", *Project Appraisal*, Vol. 9, No. 1, (March 1994)

⁵ At least three software programs are available for this purpose: *RiskEase*, *Crystal Ball* and *@risk*.

⁶ For the symmetrical distributions (uniform, triangular, and normal), the range is completed by indicating the minimum and maximum values. For the normal distribution, the range can also be set by specifying the mean and standard deviation. For the step and discrete distributions, it is necessary to define a series of intervals or discrete values along with their probability weights. These probabilities must add up to one.

⁷ For example, when dealing with the projected traffic on a new road, the projected number of visitors to a clinic, or the projected number of students in a classroom, the opinions of experts should be utilized in identifying the probability distributions and ranges.

⁸ It should be noted that the larger the number of input risk variables, the harder it is to determine the minimum number of runs to obtain plausible results, but given the speed of computers, this does not represent an obstacle as we can afford to be conservative and run a large number of simulations.

- h) Present a series of statistical measures such as the expected financial NPV, economic NPV, and variability of the outcomes.

Statistical measures of the project outcomes generated from Monte Carlo simulations are important. They are briefly described below.

- a) *Expected Value*: The expected value is a probability-weighted average of the outcomes of the simulation runs. Since the probability of each run is equal to the inverse of the number of simulation runs, the expected value is the same as the arithmetic mean of the results (e.g., the mean NPV).
- b) *Variability and Risk*: The variability of the outcomes can be measured by their range (maximum value minus minimum value), their variance, or the coefficient of variation which is the standard deviation divided by the mean.

The riskiness of a project can also be measured by the probability of getting a negative outcome, which is displayed as the expected loss from the project. The *expected loss* and *expected gain* provide a measure of the cost associated with making the wrong decision when approving or rejecting a project. The expected loss is a probability weighted average of all the negative outcomes. It is the expected value of the loss that might be incurred following a decision to accept a project. It is important because it gives an indication of what is really at stake (or at risk) from taking a decision to invest in the project. On the other hand, the expected gain is a probability-weighted average of all the positive outcomes. It is the expected value of the gains forgone following a decision to reject the project.

The expected loss ratio (*el*) defines risk to be dependent on both the shape and position of the cumulative probability distribution of returns (e.g., NPVs) relative to the zero “cut-off” mark. The ratio is calculated as the ratio of the absolute value of the expected loss divided by the sum of the expected gain and the absolute value of

the expected loss as follows:⁹

$$el = \frac{|\text{Expected Loss}|}{\text{Expected Gain} + |\text{Expected Loss}|}$$

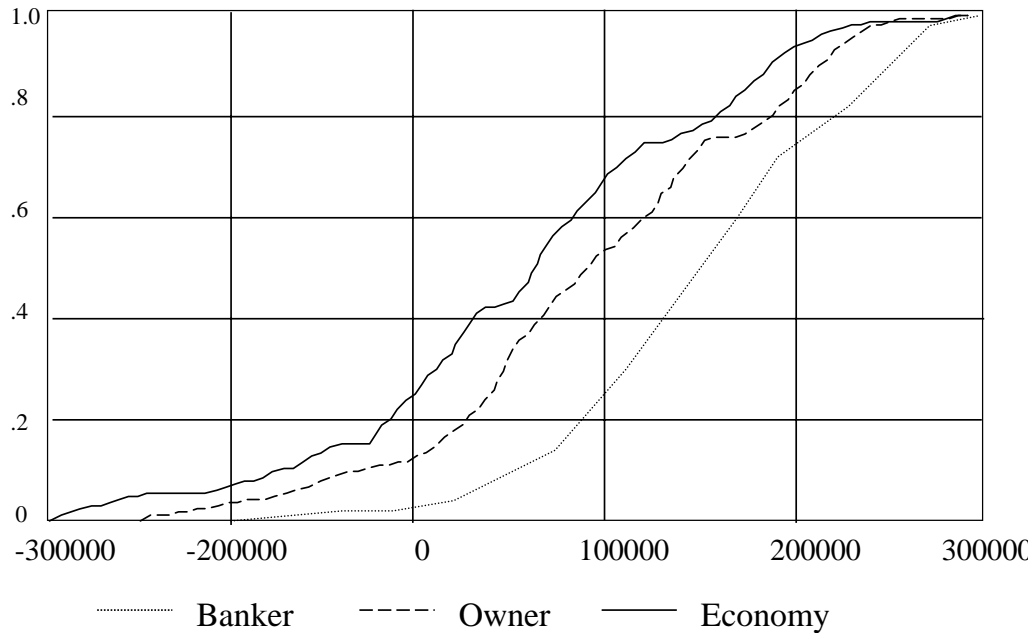
The expected loss ratio can vary from 0 when there is no expected loss, to 1 when there is no expected gain.

Instead of a single point-estimate of a project's NPV, Monte Carlo simulation generates a probability distribution of the NPVs based on the underlying uncertainty surrounding each of the key risk variables. The main question is how this additional information alters our decision criteria for accepting or rejecting projects.

The distribution of NPVs can be presented as either a frequency distribution or as a cumulative probability distribution. Figure 6.1 illustrates the latter for NPVs from three points of view: the owner, the bankers and the economy. Any point on the cumulative probability distribution indicates the probability that the NPV will be equal to or less than the corresponding value on the horizontal axis. By the same token, one minus any point on the cumulative probability distribution indicates the probability that the NPV will be greater than the corresponding value on the horizontal axis. The farther to the right is the distribution, the more attractive is a project. Several decision rules can be drawn below.

⁹ These measures of risk and the decision rules relating to Monte Carlo simulation presented below have been taken from Savvides, S.C., "Risk Analysis in Investment Appraisal", *Project Appraisal*, Vol. 9, No. 1,

Figure 6.1
Net Present Value Distribution: Cumulative Probability



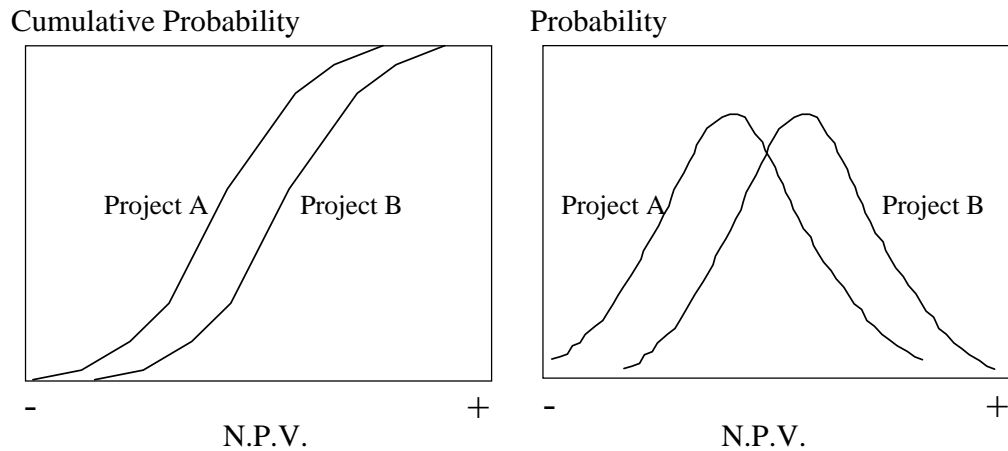
Decision Rule 1: If all of the cumulative probability distribution lies to the right of the zero “cut-off” mark, then the NPV has zero probability of being negative. One should therefore accept the project.

Decision Rule 2: If all of the cumulative probability distribution lies to the left of the zero “cut-off” mark, then the NPV has no chance of being positive. One should therefore reject the project.

Decision Rule 3: If the cumulative probability distribution crosses the zero “cut-off” mark, then there is a risk of having a negative NPV that must be weighed against the probability of getting a positive return. The investment decision is indeterminate through purely objective criteria. It really rests on the risk profile of the investor. The cost of making a mistake about whether to approve a project, as measured by the expected gain and the expected loss, and the magnitude of the probability of a negative NPV are factors that should be taken into account in making this decision.

Decision Rule 4: If the cumulative probability distributions of the returns of two mutually exclusive projects do not intersect at any point, then one should always choose the project whose probability distribution curve is farther to the right (Figure 6.2). This is because given the same probability, the return of project B is always higher than the return of project A.

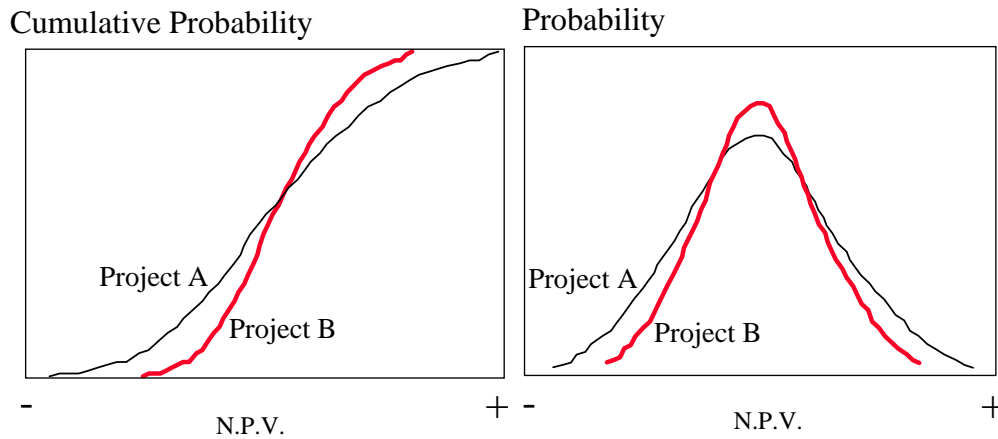
Figure 6.2
Mutually Exclusive Projects: One with a Higher Return



Decision Rule 5: If the cumulative probability distributions of the returns of two mutually exclusive projects intersect at any point, then the decision rests on investors' risk predisposition. In Figure 6.3, project B is less risky than project A. However, the expected value of project A's NPV could be higher than that of project B. Whether the added return of project A is worth the added risk depends in part on the degree of investors' risk aversion. The rules, given the risk predisposition of the investor, are shown below:

- (i) If risk neutral, then it is uncertain which project is best.
- (ii) If risk averse, then project B may be preferred to project A.
- (iii) If risk lover, then project A may be preferred to project B.

Figure 6.3
Mutually Exclusive Projects: High Return versus Low Loss



6.5 Risk Management with Contracts

Any step that can be taken to reduce the variability of the returns of a project will generally help to reduce its risk. One way to reduce a project's risk exposure is to enter into contractual arrangements. In the case of certain commodities, forward and futures contracts can be bought or sold to hedge risks. Gold or platinum producers, for example, can sell futures contracts to lock in a price today for delivery at some time in the future. While these futures markets are very useful for an operating company, the duration of the contracts is usually short and they can be costly to obtain. Consequently, they often do not provide the kind of sufficiently long-term contracts that would allow a new mining company to be established. That is why companies seek to secure long-term contracts that will permit them to arrange their financing, to invest in the necessary physical capital, to hire workers, and to begin operations in a stable environment. The key to a stable environment is managing risks in such a way that the parties to a contract have incentives to abide by the terms of a contract and to avoid actions that would undermine it.

6.5.1 Risk Reallocation

In order to manage risk a way must be found to redesign or reorganize a project in order to reallocate risk efficiently. The aim is not just to reduce risk to one party by shifting it to others -- a zero-sum game -- but rather aim for an efficiency perspective, where with the right contract one party can gain substantially without corresponding cost to the other parties. The objective is to reallocate risk to those who can best bear it. This section explores how contracts (i.e., contracts with purchasers, suppliers, and workers that govern the operation of a project) can be used and implemented to share risk efficiently.

Contract efficiency has a number of attributes. One of these is the degree of risk aversion. Customers or suppliers who are perhaps more optimistic or who are simply less averse to taking chances are more willing to accept risk; they will assign a lower cost of risk to an uncertain situation than others less willing to “go out on a limb”. Another attribute of efficiency is the comparative advantage of different project participants to diversify risks. For example, large international mineral contractors are able to diversify geologic risks by undertaking exploration activity in many sites around the world.¹⁰ They are better able to reduce that risk than the government, or an organization that owns one potential reserve.

(a) *Risk-Sharing Contracts that Limit the Range of Values*

If a project’s risk is deemed to be unacceptably high, then one should first identify and isolate the key sources of risk. For example, suppose that a project to build a water pipeline has been proposed. The water is going to be used for mining activities. A pipeline requires a major capital expenditure, and at the very least it is likely that lenders will require assurances

¹⁰ Blitzer, C.R., Lessard, D.R. and Paddock, J.L., “Risk-Bearing and the Choice of Contract Forms for Oil Exploration and Development”, *The Energy Journal*, Vol.5, No.1, ((1984) provide a comparison of alternate contracts for off-shore oil exploration in Ecuador.

that the debt service for the pipeline will be met. To be economic, the pipeline must be used at a high rate of capacity utilization to justify its costs.

- i) A common type of contract for this type of projects is a take-or-pay contract that would bind potential water users (the mineral companies) to take a certain volume of water when the product is available or to make at least minimal payments sufficient to cover debt service on the pipeline. The mineral companies that will use the water are offering assurances to water suppliers and indirectly guaranteeing the debt service for lenders. The mineral companies might be willing to enter into such a contract in order to have the pipeline project proceed.¹¹
- ii) Suppose, instead of a water pipeline, the project is a pipeline to transport natural gas to be used for industrial purposes. One possible contractual arrangement to ensure the uninterrupted sales revenue of natural gas at the required level could be a specific price-escalator clause that would index the price of natural gas to the prices of close substitutes, e.g., coal or oil. This provision would cause gas suppliers and customers to share any oil price risk, and it would help protect the pipeline from a drastic decrease in throughput.
- iii) Another approach that could be used to attract and retain customers would be to offer customers a limited product-price range. In this scenario, gas suppliers would offer their customers a ceiling on gas prices. Suppliers would thereby assume the risk of natural gas prices above the ceiling. Typically such a contract will have to be approved by the lenders to ensure that there is no due strain on the project's ability to repay its debt.

Another source of risk might be the availability of natural gas for the pipeline. Suppliers may have to be induced to give this pipeline project through such measures as *minimum quantity guarantees*. If a *minimum gas price* for natural gas is used to induce supply, purchasers would be signaling their willingness to assume more of the price risk. *Bonuses* could be

¹¹ In some situations, the much stricter “all-events-full-cost-of-service-tariff” arrangement can be used. Under such a contractual arrangement, customers are obligated to pay under all circumstances, i.e., whether the product is available or not. This type of contract is sometimes referred to as a hell-or-high-water contract because purchasers must pay “come hell or high water.”

offered for maintaining consistency of supply, and *penalties* could be imposed for supply interruptions. Where the quality of the goods supplied is an issue, supply contracts would also have to include terms that would clearly state the minimum acceptable quality.¹²

These types of arrangements can be analyzed by incorporating the contract terms into a spreadsheet model. For example, *take-or-pay contracts* can be modeled using the “If” function in Excel. *Price-escalator clauses* can be introduced as equations linking gas prices to oil or coal prices; the oil and/or coal prices may themselves be risk variables for simulation purposes. Contract limitations that establish floor, ceiling prices or delivering minimum quantities can be captured while modeling the risk analysis.

The effect of these contract provisions is to change the expected value and/or the variance of the distribution of project outcomes. An increase in the expected value or a decrease in the variability of project outcomes would make a project more attractive to investors. For example, the introduction of a ceiling price on natural gas could be modeled by truncating the distribution of gas prices at that ceiling. The truncation has the effect of taking the probabilities of a price above the ceiling and assigning them to that value.¹³ The results are twofold: the expected price of natural gas would be lower, and the variance of the gas revenue would be lower because the range of possible values is reduced. This contract provision would make the project more attractive to customers and less attractive to gas suppliers. Provided that gas suppliers would continue to fulfill their contracts, investors might find the pipeline project to be more attractive because gas customers have a greater incentive not to switch fuels. While the project may have given up some of its returns through this contract, it also reduces the variability and riskiness of these returns.

¹² It should be noted that when re-allocating risk through risk-sharing agreements it is important to maintain viability across the chain of intermediaries that are crucial in taking the product through to the final consumer. A risk sharing contract which puts a vital intermediary in a precariously non-viable position will risk the success and the viability for all the stakeholders in the project.

¹³ If in the simulation process the price of natural gas were above the ceiling, then the model would insert the ceiling price; if the price of natural gas were below the ceiling price, then the model would use the market price. Glenday, G., “Monte Carlo Simulation Techniques in the Valuation of Truncated Distributions in the Context of Project Appraisal”, paper presented at 64th Annual Conference of the Western Economic Association, (June 1989); and Glenday, G., “Risk Sharing Contracts in Project Appraisal”, *Canadian Journal of Program Evaluation*, (1997).

(b) *Risk-Sharing Contracts that Establish a Correlation between Revenues and Costs*

A reduction in risk can arise from establishing a correlation between sales revenues and costs. This result is based on the same principle as portfolio diversification in which the variance of the sum of two random variables that are combined in certain proportions is equal to the weighted sum of their individual variances plus a covariance term:

$$V(ax + by) = a^2V(x) + b^2V(y) + 2abCov(x, y) \quad (6.1)$$

where x and y are two random variables, and a and b are two constants that could be scale factors or proportions.

In the context of risky net cash flows, let x be sales revenues (R), y be costs (C), $a = 1$ and $b = -1$. Equation (6.1) then becomes:

$$V(R - C) = V(R) + V(C) - 2Cov(R, C) \quad (6.2)$$

The variance in the net cash flows, $R - C$, is equal to the variance in cash receipts plus the variance in costs *minus* two times the covariance between receipts and costs. If a contract can be drawn up that will create a positive correlation, and hence a positive covariance between cash receipts and some of the cost items, and if in the process the variance of the costs does not increase by more than twice the covariance, then the variance of the net cash flows will be less than the sum of the variances of receipts and costs. Simply put, when the revenues and costs move in tandem, there will be less variability in the project's returns.¹⁴

Examples of such contracts include indexed bonds¹⁵ and profit-sharing agreements with

¹⁴ The reduced variability also puts a ceiling on the "risk-upside" which is the possibility of excessive returns.

¹⁵ A number of years ago, Pemex, Mexico's state-owned oil company, issued bonds whose interest rate was

workers. In a profit sharing agreement, let g stand for a proportion of the total costs (C) that is still paid to workers as a wage and h be the labor's share of profit after wages have been paid. Thus, the total cost will become: $C = gC + h(R - gC)$ where R stands for gross revenue. The net profit will be equal to: $R - C = R - gC - h(R - gC)$. The variance of net profit will be:

$$v(\text{net profit}) = (1-h)^2v(R) + g^2(1-h)^2v(C) - 2g(1-h)^2\text{cov}(R,C) \quad (6.3)$$

If $0 < g < 1$ and $0 < h < 1$, then the variance of net profit will be lower than it was without the agreement. Thus, any contract that creates a positive correlation between revenues and supply costs would likely have a similar effect.

(c) Other Risk-Reallocation Techniques

Contingent claims analysis can be used to value options that are available to either project managers or investors to manage risks. It is clearly advantageous if a firm is able to switch product lines, production techniques, or input suppliers, to expand capacity if sales are growing rapidly (where failure to expand could mean the loss of sales to larger firms), or to suspend production if revenues do not cover variable costs. The problem of quantitatively assessing overall project flexibility is beyond the scope of this manual, but the underlying principles should be kept in mind.

6.5.2 Contracting Risk

Contracting risk refers to potential unilateral departures from the contract terms by one party that may jeopardize the other party's position.¹⁶ If a contract is one-sided, or if circumstances arise that would cause one party to take actions under the terms of a contract,

indexed to the price of oil. When the price of oil rose, then interest rates would be higher, but then Pemex would be better able to afford the higher rates; when the price of oil fell and the company was squeezed for cash, then interest rates would be lower which would help to keep the net cash flow to equity positive.

¹⁶ Blitzer, C.R., Lessard, D.R. and Paddock, J.L., "Risk-Bearing and the Choice of Contract Forms for Oil Exploration and Development", *the Energy Journal*, Vol.5, No.1, ((1984).

then that party is likely either to take defensive or evasive actions or to simply walk away from the project.

For example, if a supplier has agreed to a price ceiling on materials that are used as inputs to a project, but due to shortages the market price for the materials has risen substantially above the ceiling, then the supplier has an incentive to take actions that would weaken the impact of the price ceiling. These actions might include the substitution of lower quality materials, or delayed deliveries. The effect of such actions would be to reduce overall product quality or to disrupt regular production runs to such an extent that project managers would be willing to re-negotiate the price-ceiling clause in the materials contract. These negotiations may take time and could disrupt a project's normal operations. This is why an efficient contract does not load too much risk, given the compensation, on one party. An efficient contract is a stable contract that is able to withstand unanticipated shocks without costly gaming behavior or frequent re-negotiation.

6.5.3 Incentive Effects

Efficient contracts can sometimes not only offer an improved allocation of risk, but also an incentive structure that will encourage project participants to change their behavior in such a way as to improve project outcomes. Whereas risk sharing takes the distributions of the risk variables as given and tries to re-allocate risk to those who can best bear it, risk management provides incentives for participants to alter their behavior so as to change the probabilities of the outcomes. The challenge is to design a contract whose incentives are compatible with the project's objectives.

Many of the incentive problems that arise with a project are due to imperfect and/or asymmetric information. This gives rise to the so-called principal-agent problem where the principal (owner) of the assets would like the agent (manager, employee) to manage the assets in the best interests of the owner. The problem is that the agent may understand the operations of the project better than the owner, and the agent probably has better data and information about how the project is progressing. It is very difficult for the owner to monitor

thoroughly the manager's activities and performance, and hence, the manager has some leeway to pursue his/her own objectives rather than those of the owner. The result is a less than fully efficient operation.

For example, workers who enter into a profit-sharing agreement and who possibly have membership on the company's board of directors, will have more information about the company's financial situation and will experience a different set of incentives than salaried workers. Profit-sharing workers, on the one hand, will not only share in the risks, but will also be more willing to engage in activities that will help to boost profits. Salaried, or hourly paid employees, on the other hand, would be more inclined to pursue their own interests (e.g., longer lunch hours, more vacation time, etc.), which are unlikely to be the same as those of the owner.

Managerial incentives can also be affected by contracting risks, mentioned in the previous section. If managers are suspicious of the owner's (government's) intentions, then they will take actions to benefit themselves at the expense of the owners. This could mean running the equipment for more than the optimal number of hours, failing to observe maintenance schedules, or failing to maintain good customer relations.

6.6 Risks and Mitigating Measures in Project Financing

6.6.1 Introduction

Governments' use of project finance as a source of capital for medium and large-scale development projects has increased considerably in the past two decades. Project finance has also evolved, and continues to do so, over time into different structural forms with respect to ownership, operating and financing. A common feature in project finance is that the project is structured as an independent legal entity. The ownership of the project can take one of many forms. For example, the project can be owned by a private-sector company, a government enterprise, a multinational corporation, a joint venture between private companies, or a partnership between the private sector and the government. Some of the

increasingly popular private-public partnerships that use project finance are ‘build, operate and transfer’ (BOT), and ‘build, operate, and own’ (BOO).

Project financing typically refers to *Limited Recourse Financing* where the project’s lenders have recourse to the owners in certain situations only. In other words, some of the project’s risks are borne by the lenders while others are borne by the sponsors or other credit-worthy third parties. For example, lenders could have full recourse to the owners until the project is complete after which their only recourse is to the project’s assets and cash flows. Limited recourse financing falls between two extremes: full recourse financing which is similar to corporate (collateral-based) lending and non-recourse financing where the lenders’ only recourse is to the project’s assets and cash flows.¹⁷

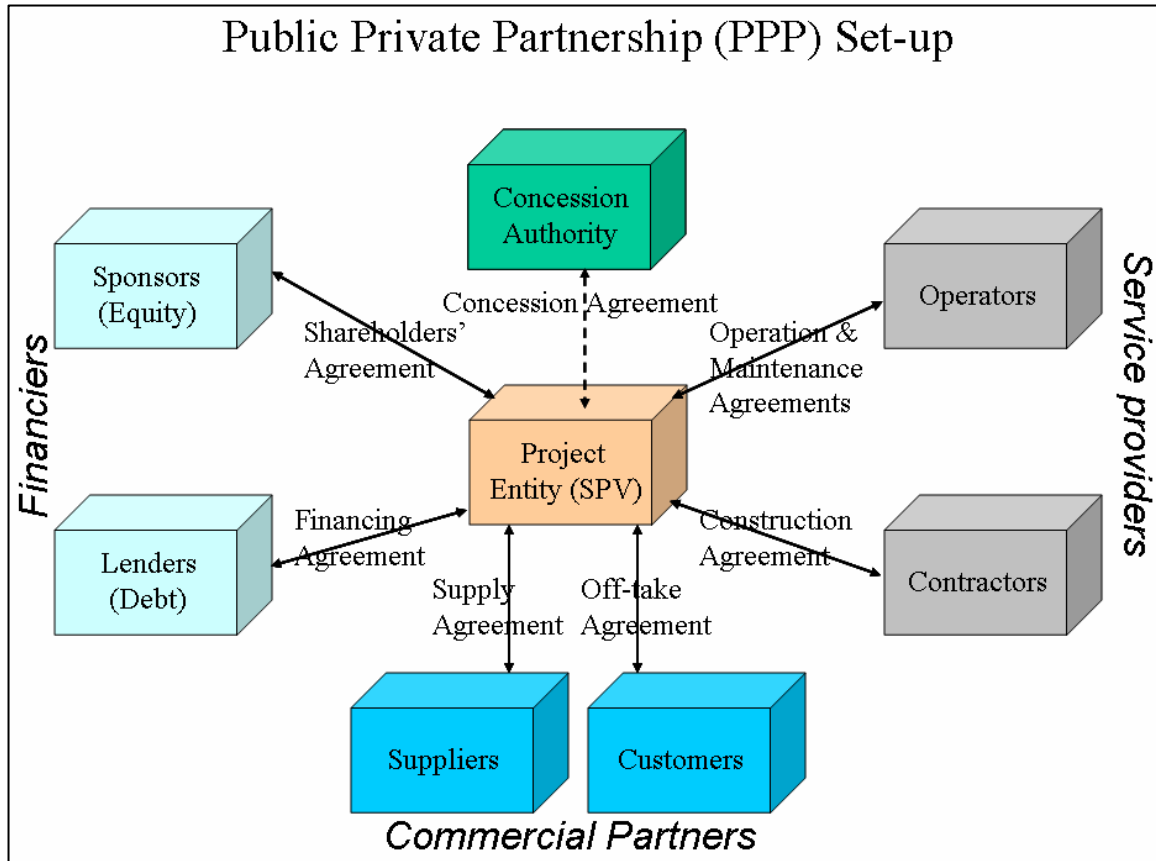
Project finance started in the oil and gas industry where sponsors wanted to reduce their risk exposure and preserve their borrowing capacity and the lenders were protected by the large profit margins of that industry. Since then, the scope and use of project finance has expanded and continues to do so. At present, it finds wide applicability in the financing of infrastructure as international and regional banks encourage the undertaking of these investments by private sector companies or through public-private partnerships. Project finance is no longer limited to large-scale capital projects, as medium-scale projects with capital costs as low as US\$5 million have begun to use project finance to raise capital. Many industrial projects are financed in this manner.

A typical project finance set up is displayed in Figure 6.4 below. The project entity -- the special purpose vehicles (SPV) -- makes appropriate contractual agreements with Service providers, Commercial partners and Financiers. The latter make sure that the agreements are in place so that the project represents a bankable risk. A project finance structure becomes a “Public Private Partnership” when a public authority is directly involved and makes available to the project public sector assets and other resources through a concession

¹⁷ See Beale, C.S., “Trends in Limited and Non-Recourse Financing”, a speech delivered to a project financing conference, (1984); and Niehuss, J.M., “An Introduction to International Project Financing”, edited by Hellawell and Wallace, D. Jr., *Negotiating Foreign Investments: A Manual for the Third World*, International Law Institute, (1982).

agreement for the purpose of undertaking and executing an economic development project (such as an airport, a motorway or a port and marina development).

Figure 6.4



Governments in developing countries are increasing their utilization of project finance as a major source for raising capital for large projects. The use of project finance through BOT arrangements in particular has become quite popular for large infrastructure projects in the power, water and transportation sectors. The use of BOT enables the governments to tap sources of capital that were not otherwise available, attracts the required expertise, or perhaps enhance the technology transfer process.

Project finance is not without its disadvantages and can be a more expensive means of finance than corporate (collateral-based) borrowing. The higher cost of project finance loans

is attributed to higher interest rates and other charges and fees that are only applied to project lending. The higher interest rates are in part attributable to the additional risk that the lenders are being exposed to, and in part is compensation for some of the expenses incurred in carrying out the different studies and in putting the deal together. These expenses and fees also include commitment fees, management fees paid to the lead underwriter, participation fees paid to other banks if the loan is syndicated, selling fees, legal fees, etc. In addition, closing project finance agreements is a lengthy and time-consuming process that often takes a few years and projects' sponsors end with incurring some additional costs in putting the deal together.¹⁸ Nevertheless, the main risks associated with project finance are better understood both by the project's lenders and owners and as a result contracts and other mechanisms are appropriately used to mitigate, spread out and manage the risks.

6.6.2 Contractual Arrangements and Other Mechanisms for Mitigating Project Risks

Project risks and mitigating mechanisms are commonly approached from the point of view of the lenders. While the risks belong to the project, the mitigation mechanisms and contracts considered typically seek to eliminate or reduce the risk to a project's lenders. It is imperative that project sponsors analyze the risks and propose contracts to ensure that risks are being shifted in the most efficient way so that are being undertaken by those project participants best equipped to bear them.

One of the misconceptions associated with risk in project finance is that lenders take a lot more risk when involved in project finance than they do in conventional corporate lending. This is not necessarily true. Banks have enhanced their capabilities of analyzing projects by hiring the necessary expertise. Consequently, their understanding of the nature of a project's risks and their magnitudes has improved significantly. This enables lenders to accept some low risks that they might not have accepted in the past had they not carried out detailed

¹⁸ For example, the undertaking of independent studies for the evaluation of reserves and certain risks, the negotiation and preparation of the different contracts, the setting up of certain funds, etc. all contribute to raising the cost of project financing to a project's sponsors.

project studies. Since these detailed analyses are not commonly undertaken for projects using corporate lending, it may appear that lenders are bearing substantially more risk with project finance.

The critical period for most projects is the completion of the project and its preparation for operation. Lenders generally divide risks into two broad categories, pre-completion risks and post-completion risks. These risks and ways to manage them are briefly discussed below.¹⁹

(a) Pre-Completion Risks

Pre-completion risks include completion risk and participant risk. Completion risk is the risk that a project may not be completed. Completion is defined in physical, mechanical and financial terms. Physical completion risk is the risk that the construction will not be completed within the specified time and budget, or will not be completed at all. Time delays generally translate into cost overruns as well due to, among other things, accrued interest during construction and increases in the general price level. Mechanical or technical risk is the risk that the project cannot sustain production at a specified capacity for a specified period of time. Financial completion risk is the risk that the project cannot produce under a certain unit cost or that it cannot meet certain financial ratios for a specified period of time.

Lenders rarely accept completion risks and seek some sort of completion guarantee from the sponsors. These guarantees may take one of several forms. If the project is not completed on time or if there are cost overruns, project owners may be required to pay back the debt. Alternatively, project owners may be asked to absorb the project debt as a liability of the parent company and pay it according to a specified schedule out of the company's cash flows. A third alternative is for the project sponsors to guarantee completion by financing any overruns using new equity. It is clear that any of the above guarantees imply that prior to completion, project debt is treated as full-recourse debt or basically as the sponsors' debt. In

¹⁹ More extensive discussions of the various risks can be found in various references such as Nevitt, P.K. and Fabozzi, F., *Project Financing*, Rochester: Euromoney Publications, (1995), Chapters 10 and 11; Finnerty, J.D., *Project Financing – Asset-Based Financial Engineering*, New York: John Wiley and Sons, (1996),

the case of large development projects that are beyond the financial ability of the sponsors, the government may be called upon to provide a completion guarantee.

Any of the above guarantees largely reduces the risk that the project will not be completed. In other words, by virtue of any of these guarantees, bankers have shifted the entire completion risk to the project sponsors or a creditworthy third party. The project's owners on the other hand should not be indifferent between guarantees.²⁰

The project's sponsors should also attempt to shield themselves from the completion risk or part of it, if possible, by passing it on or sharing it with other stakeholders. One way to accomplish this is through a turnkey arrangement or a fixed-price contract with the contractor undertaking the construction of the project.²¹ The project's analysts should assess whether the additional cost incurred in commissioning a turnkey project is necessary or not. In other words, has the contractor completed similar projects in the past on time and within budget? Have there been delays? Do they warrant a fixed-cost contract? Will the lenders be willing to accept the turnkey contract as their completion guarantee?

In certain situations, the project's lenders may agree to share construction cost overruns up to a limit with the project's sponsors. Owners can pre-arrange other sources of cost-overrun funding such as standby lines of credit. This will depend on the strength of the project's cash flows and whether they can cover additional debt repayments or not.

Lenders may be willing to share financial completion risks if they appear to be relatively low. Various conditions must be satisfied before lenders are willing to fully or partially accept completion risks. For instance, the project must be using a proven technology.

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²⁰ For example, assuming the project debt as parent company debt may implicitly entail the first guarantee, which is to pay off the debt, hence providing more flexibility. When guaranteeing to complete the project from equity funds, will the sponsor commit unlimited funds or does a cap exist? Perhaps a guarantee that has some elements from each of the three guarantees mentioned above will work best for the sponsors without compromising the lenders. Another question that should be addressed is how force majeure is handled during the completion phase.

²¹ The most common of such contracts are known as an EPC contract. EPC is referring to a contract covering engineering, procurement and construction obligations.

Lenders will seldom take the completion risk in the case of a new technology. Lenders will also require that the contractor have sufficient experience in undertaking similar projects and in completing them on time; the expected cash flows are strong enough to withstand substantial cost overruns; the project management and staff are competent; procurement has been secured early, and the political climate is stable. In a few cases and when all these conditions hold, some projects have succeeded in obtaining non-recourse financing from the lenders. Such non-recourse financing is more common for oil and gas production projects than for projects from other sectors.

One or more of the project sponsors may be financially weak. In such case, a financially weak sponsor may not be able to meet his financial obligations. Under certain legal structures for ownership, each individual sponsor is responsible for his share of the project's financial obligations and debt. If lenders are concerned that there are weak participants among the sponsors, they may require cross default clauses on non-defaulting borrowers for the default of another borrower. An alternative that lenders may resort to is to seek third-party credit support for the weak sponsor(s). The most common form of this support is a letter of credit. If the lenders are concerned about the commitment of one of the sponsors, they may require pre-committed and/or additional equity which will reduce their overall exposure to the project by lowering the debt/equity ratio.

From the sponsors' perspective, the cross default may add to the financial burden of the non-defaulting borrowers and so may not be desirable to all sponsors. It may be possible, however, in certain cases that the non-defaulting sponsors assume the debt of the defaulting sponsor and buy his share in the project. If cross-default is not acceptable to the sponsors, third-party credit support or pre-committed equity may be preferable solutions.²²

(b) Post-Completion Risks

Post-completion risks include raw material risk, resource risk, operating risk, market risk,

²² The legal structure of the project entity and issues of default need to be considered carefully to avoid any unexpected disruption to the project and distress to any of its sponsors before completion.

political risk, force majeure risk, abandonment risk and so on.

(1) *Raw Material Risk*

Raw material risk is the risk that the project will not be able to secure the sufficient supply of any of its raw materials to ensure the timely production of the project's output. This disruption may in-turn jeopardize the sponsor's ability to service the project's debt. Raw material risk includes the risk of unavailability and the cost risk. If the project's sponsors do not own the sources of the project's main raw materials, lenders often require that the project have firm contracts with the suppliers of the project's main raw materials.

Such contracts are not only beneficial to the lenders but also to the project's sponsors. First, obtaining this contract helps secure the financing for the project. Just as important, it provides a great incentive to the supplier to adhere to the specified delivery schedule. These contracts can take the form of *supply or pay*. Under this contract, a creditworthy supplier is committed to deliver the required amount of raw material to the project or to pay the project so that it can service its debt. How the suppliers can recoup such payments, if at all, is something that can be specified in the contract.

These contracts need not be zero-sum contracts where one stakeholder has to lose for the other to gain. Long-term contracts with the project's suppliers can be beneficial to both the project's owners and the suppliers of the raw materials. For example, the supply price specified in the contract can be based on the long-run price of the raw material and can be indexed to reflect changes in the general price level or linked to the price of a close substitute. Alternatively, the input price can be linked to the price of the output itself.

Project owners will gain by securing the supply of the raw material at a price to be determined according to an already specified formula. The supplier of the raw material can also gain by securing a stable income stream. Both the owners and suppliers are likely to gain due to a lower variability over time in their cash flows as a result of the contract. In some instances, it may be beneficial to the project's owners to pay a premium to secure a

long-term supply-or-pay contract with its raw material suppliers. The availability of a spot market for the raw material can generally reduce the need for a contract to secure the long-run supply.

(2) *Resource Risk*

The resource risk is limited to mining projects. It is the risk that the mine will not have sufficient recoverable reserves. To deal with this risk, lenders often carry out their geological surveys and analyses, or require the sponsors to carry out independent studies, to ascertain the quantity and quality of mineable reserves. Typically, lenders will consider providing project finance to a mining project if the amount of reserves to be mined is at least twice or more than the planned production. In other words, the loan repayment period should not exceed half the mine's life. Whether the lenders have the technical staff to conduct their own analysis or the project's owners will commission an independent investigation, this imposes an additional cost on the project's sponsors. This additional cost manifests itself either in higher interest rates charged by the lenders, or increased expenditures to pay for the study. For projects that prove to have satisfactory reserves, lenders may be willing to assume the completion risk or at least share it with the sponsors of the project.

(3) *Operating Risk*

This is the risk that the project may run into some operating difficulty, which impedes its ability to generate sufficient cash flows to service the project's debt. In the case of proven technology and experienced operators and managers, lenders are usually willing to assume the operating risk. If the technology is relatively new, lenders will require performance guarantees from the equipment suppliers. With unproven technology, it is safe to say that project financing, if made available, will approach full-recourse financing, as the lenders will require at least completion guarantees and operating guarantees from the equipment supplier or the technology provider. The guarantees will only be accepted if the supplier or technology provider is creditworthy.

(4) *Market Risk*

The market risk is the risk that the project will not be able to generate enough revenues and cash flows to service its debt due to either low market prices of the output or an inability to sell the expected volume or a combination of both. The risk of a low market price is known as price risk and the risk of not selling sufficient volumes is known as volume risk. However, it should be noted that this standard way of describing market risk is an oversimplification of what is usually the main cause of failure of major projects.²³ Market risk is in fact both the most critical and the most difficult part to assess and evaluate in cost-benefit analysis. This is because it revolves around the wider and deeper subject of what constitutes project competitiveness.²⁴

Lenders will be looking for guarantees that the output of the project will be sold. This requires long-term sales contracts for the project's output. Several types of sales contracts exist. Under a *take-and-pay* contract, the project's customers commit to buying a certain amount of the project's output if it is made available by the project. In other words, the project's customer will have to take and pay the amount agreed upon even if the customer does not need it. This is perhaps the most often used of the long-term sales contracts, although not the preferred one by lenders. Such contracts should in principle be avoided as being too one-sided but may be necessary in some situations in order to make the project financeable. For example, an independent power producer will require such a contract from the utility to ensure continuous and sufficient sales.

The *take-or-pay* contract is a variation of the take-and-pay contract. Under the provisions of this contract, the project's customers will pay for a fixed amount of the product whether available or not. A more radical form of the take and pay is the "hell or high water" contract

²³ Flyvbjerg, B., Bruzelius, N. and Rothengatter, W., *Mega Projects and Risk*, Cambridge University Press, (2003).

²⁴ For an introduction on the subject of market analysis and the assessment of competitiveness of a project's market risk, see Savvides, S.C., "Market Analysis and Competitiveness in Project Appraisal", Harvard Institute for International Development, Development Discussion Paper No. 755, (February 2000).

under which customers pay even if the plant breaks down or if stoppage is related to force majeure.

Throughput and cash deficiency agreements are generally associated with pipeline projects. A throughput agreement stipulates that a specified amount of gas or oil will have to be shipped through the pipeline in a certain period of time. The specified amount is enough to generate sufficient revenues so that the project can pay all expenses and service the debt. A cash deficiency agreement complements the throughput agreement by requiring the shipping companies to make cash payments to the project if for any reason the project does not have enough cash to service the debt. This payment by the shipper can be treated as an advance to the project and settled in the future in a manner that does not hinder the project's viability or its capability to service its debt.

All of the contracts mentioned above primarily secure specified sales (volume) levels but can be also used to set prices as well. For example, the project's sponsors can agree with its customers on an initial selling price and a formula for indexing this price over time. The formula can include changes in general price levels, input prices, costs of substitutes, etc. Although including a large number of variables may sound conceptually appealing, it is likely to complicate the price estimation. In some cases, minimum prices can be specified in the contract.

When designing and analyzing these contracts, all contracting parties should be creditworthy, and contracts should be reasonable and fair from all perspectives. Otherwise, contracts can, and will, be breached. Building some flexibility in the contracts is also advisable to avoid unintended hair-trigger breaches that are the outcome of rigid clauses in the contracts.

The design of contracts can get more involved and complicated when it deals with multiple issues. Suppose, for example, that we have two projects, an oil-production project and an oil refinery. The refinery may wish to pursue throughput and cash deficiency agreements with the oil production project to ensure a continuous supply. At the same time, the oil production

project may wish to pursue a take-and-pay contract with the refinery to ensure the sale of its output. While the first set of agreements protects the lenders to the refinery against some risks, the second contract would increase the refinery's risk and hence have a negative impact on the refinery's ability to service its debt.

Another consideration when designing contracts is whether the entire output of the project should be under contract or not. The objective is that the cash flows guaranteed by contract cover the debt servicing. If this is accomplished by having only a proportion of the project's output under contract, the lenders may be readily agreeable to accepting long-term sales contracts that only cover a portion of the project's output.

(5) *Force Majeure Risk*

Force majeure risk is the risk that something outside the control of the lenders and sponsors would hinder the operations of the project. This includes natural disasters such as earthquakes and floods, and situations other than natural disasters such as strikes. Lenders may require the sponsors to seek insurance against force majeure risks, or alternatively, establish a debt service reserve fund that would be used to service the debt in such an eventuality. The financing provisions can also be structured in a way that allows for some restructuring in the case of a force majeure.

(6) *Political Risk*

Political risk covers a range of issues ranging from nationalization, expropriation, currency inconvertibility and other controls on capital, changes in tax laws and so on. Some of these risks may be motivated by environmental concerns, the importance of which continues to increase worldwide and in developing countries in particular. Political risk is a concern for joint ventures and multinationals undertaking projects in developing countries.

There are several ways to protect the project's lenders against these risks. Governments can provide guarantees that the project will not be subjected to any of these political risks.

Alternatively, governments can provide a guarantee that they will assume the project debt if the project is adversely impacted by any of these political actions. Project sponsors can also insure the project against political risks. Insurance can be sought from official sources such as the Multilateral Investment Guaranty Agency (MIGA) from the World Bank group and the Overseas Private Investment Corporation (OPIC) in the USA. Project sponsors can also seek private insurance from insurance organizations, such as Lloyds, that undertake such risks.

Political risk can be also mitigated if large international and regional financial agencies (such as the World Bank, the African Development Bank, the Asian Development Bank, and the International Finance Corporation) that have various other dealings with the country are involved. In fact, it may be to the benefit of the project in the host country to involve one or more of these financial agencies to signal the country's seriousness and commitment to the project.

Certain political risks can be avoided by establishing offshore escrow accounts to be held in sound financial institutions. In such cases is a trust fund typically created outside the project's country. The purchaser of the project's output will agree to deposit the proceeds of the sales directly into the fund. The trustees of the fund are obliged to service the debt, maintain some reserves, and then release the remainder to the project's sponsors. This mechanism is more readily applicable if the project's output is exported and the receipts are generated overseas. This scheme may be difficult to implement if the project's output is non-tradable and not generating foreign exchange. In other words, it may be difficult to use an offshore escrow account for infrastructure projects such as power, water and wastewater and road projects.

(7) Abandonment Risk

The abandonment risk is the risk that the project owners will abandon the project before all project debt has been serviced. Project lenders are concerned that the project's sponsors may abandon the project during its operation stage if it is no longer profitable to them but still

capable of generating the funds (at least partially) to service the debt. To protect themselves against abandonment, lenders formulate an ‘abandonment test’ based on historical and projected costs and receipts. If the test is met, sponsors may be allowed to abandon the project, otherwise they have to continue to operate it to service the debt. If abandonment is only under severe conditions, the sponsors may have no recourse but to pay off the debt. For example, if the test provides that the project should be operated at the sponsors’ cost while the revenues are used to service the debt, the owners may have no recourse but to pay off the debt. In other words, stringent abandonment tests can end up converting the loan from what appears to be limited-recourse financing to full-recourse financing.

(8) *Interest Rate Risk*

Floating interest rates can be risky. An increase in the interest rates can impair the project’s ability to service debt. This risk can be reduced by entering into interest rate swaps according to which a project borrowing at a floating interest rate can enter into an agreement under which it agrees to pay a fixed rate of interest and receive a floating rate of interest. Alternatively, the project owners can select an interest rate cap which is a contract that protects the borrower (the project) against increases in interest rate by obligating another party, for a fee, to pay the difference between the market interest rate and the cap rate whenever the market interest rate is higher than the cap rate. To reduce the costs of the derivative the borrower may choose a “collar” agreement which provides for a ceiling as well as a floor condition. In such an arrangement the cost of limiting the risk of high interest rates is offset against the possibility of gain in the event that the base rate falls below a certain point.

(9) *Foreign Exchange Risk*

There may be a currency risk if the project’s receipts are in one currency and its costs are in another currency. Changes in the exchange rate can have detrimental impacts on the project’s ability to service its debt. These risks can be reduced or partially hedged by taking

out a loan in the currency in which the project will receive its receipts. Alternatively, the sponsors can use the forward or future markers, or arrange currency swaps.

(10) Rigid Debt Service and Hair Trigger Defaults

The terms of the loan repayment period should take into account the economic life of the project and not put unnecessary pressure on the cash flows of the project in the early years. Rigid debt service may result in a project defaulting during a downturn even though it is still viable. To avoid these unnecessary defaults, debt servicing should be structured in a flexible manner and avoid hair trigger defaults. For example debt servicing can be positively tied to a pre-agreed index (such the sales price) or the sales revenues; whereby the servicing increases when the sales revenues are above an agreed budget and vice versa. In such cases, it is also common for the financing bank to also demand to have some leverage over the management's decision to sell within a certain price range.

(11) Syndication Risk

It is quite common for the sponsors of large-scale projects to arrange their financing through a lead underwriter from a group of banks. This group is known as the syndicate. There is always the risk that the lead underwriter will not be able to secure the financing after negotiating the basic terms and conditions with the project's sponsors. This can delay the projects for long periods of time. To avoid such delays, the sponsors can try to secure a firm underwritten commitment from the lead underwriter(s). If this approach does not succeed, the sponsor can approach a group of underwriters to finance the project without really creating a syndicate (each bank will co-finance the project based on separately negotiated loan agreements). This is commonly known as club financing or project co-financing agreements where the common factor is usually the fact that the co-financing banks make a separate agreement between them to share the available project collaterals and security available.

6.7 Conclusion

A project usually lasts for many years and faces a great deal of uncertainty including each of the future values of project inputs and project outputs, the project financing arrangements as well as the macroeconomic and political environment. The project analysis would be far from over if it ends at the stage of the deterministic evaluation. This chapter has shown how one can and must move from the analysis of a deterministic world to a probabilistic world.

We have explained that project analysts have to first identify the key risk variables of the project in question using traditional sensitivity and scenario analyses; and then estimate correlation among risk variables with historical data to the extent available or with the help from experts in the area. It takes into account the different ranges of possible values and different probability distributions for the risk variables employed in a Monte Carlo simulation of the project. The analysis presented in this chapter is indeed part of our integral project analysis approach as it integrates key risk variables into the financial, economic, and stakeholder analysis of the project. Key project evaluation criteria for the financial and economic appraisal can all be summarized and presented based on the frequency or cumulative distributions for the items of interest such as the financial NPV, the economic NPV, debt service coverage and the expected loss ratio.

With the understanding of this technique, we have presented a conceptual framework using numerous contracts to manage project risks in the most efficient manner. As project financing is also a key element for a successful project implementation, we have identified the possible pre-completion risks and post-completion risks and presented some of the mitigation mechanisms and contracts to eliminate or reduce the risks to the project's lenders, sponsors and other participants in the project.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 7:**

***PRINCIPLES UNDERLYING THE ECONOMIC
ANALYSIS OF PROJECTS***

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ABSTRACT

While the financial analysis of a project focuses on matters of interest to investors, bankers, public sector budgets, etc., an economic analysis deals with the impact of the project on the entire society. The primary difference between the economic and financial evaluation is that the former aggregates benefits and costs over all the country's residents to determine whether the project improves the level of economic welfare of the country as a whole while the latter considers the project from the point of view of the well-being of a particular institution or subgroup of the population. A broad consensus exists among accountants on the principles to be used in undertaking a financial appraisal of a potential investment. There is also considerable agreement among financial analysts on the cash flow and balance sheet requirements for a public sector project to pay for itself on a cash basis. However, these accounting and financial principles are not a sufficient guide for undertaking an economic appraisal of a project. This chapter explains the relationship between the financial and the evaluations and how the economics is grounded in microeconomic theory and its applications in welfare economics.

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CHAPTER 7

PRINCIPLES UNDERLYING THE ECONOMIC ANALYSIS OF PROJECTS

7.1 Objectives for Economic Investment Appraisal

While the financial analysis of a project focuses on matters of interest to investors, bankers, public sector budgets, etc., an economic analysis deals with the impact of the project on the entire society. The primary difference between the economic and financial evaluation is that the former aggregates benefits and costs over all the country's residents to determine whether the project improves the level of economic welfare of the country as a whole while the latter considers the project from the point of view of the well-being of a particular institution or subgroup of the population.

A broad consensus exists among accountants on the principles to be used in undertaking a financial appraisal of a potential investment. There is also considerable agreement among financial analysts on the cash flow and balance sheet requirements for a public sector project to pay for itself on a cash basis. However, these accounting and financial principles are not a sufficient guide for undertaking an economic appraisal of a project.

The measurement of economic benefits and costs is built on the information developed in the financial appraisal, but in addition, it makes important use of the economic principles developed in the field of applied welfare economics. For a person to be a proficient economic analyst of capital expenditures it is as imperative that he be conversant with the principles of applied welfare economics, as it is for the financial analyst to be knowledgeable of the basic principles of accounting. In the measurement of economic values we begin by looking to the market of a specific good or service. The initial information for measuring its economic costs and benefits is obtained from the observation of the actual choices of consumers and producers in that market.

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To better understand the nature of an economic analysis and how it relates to the financial analysis, let us consider the case of a cement plant constructed on the outskirts of a town. In the financial analysis, the owners of the plant determine the profitability and financial attractiveness of the project. If the project has a positive financial NPV, and relatively low risk, the owners will undertake the project because it will increase their net wealth.

If no one else in the country gains or losses as a result of the project, there would be almost no difference between the financial and economic analyses. Consequently, when conducting an economic analysis, it may help from a conceptual standpoint to determine what groups, in addition to the project sponsors, gain or lose as a result of the project. For example, if the cement project pays wages higher than the prevailing market wages, the excess constitutes a benefit to workers. Thus, an adjustment to reflect their benefit would have to be included in the economic analysis. If the project pays income tax, this represents a financial cost to the project owners but a benefit to the government, which would have to be estimated and included in the economic analysis. Furthermore, if one of the town's neighborhoods is affected by pollution due to emissions from the plant, the associated costs in terms of health and other lost amenities should also be taken into account in the economic analysis.

If the project's workers, town residents, consumers of cement (project and non-project) and the government represent all the parties impacted by the project, then the net economic benefit or cost would be determined by adding all the gains and losses of these stakeholders to the gains or losses of the plant owners. If the final result is a net gain, then the cement plant increases the net welfare of the economy and should be undertaken; otherwise it should not be undertaken. Note that economic viability does not require that every stakeholder perceive a net benefit from a project. Most projects will have both losers and gainers. However, if the gains outweigh the losses, the project is economically viable and should be undertaken. The underlying rationale is that a net gain implies that losers from the project could be compensated.

The above simple example explains the economic analysis of a project in its basic form. There are generally further adjustments that need to be carried out due to differences between the market price and the economic price of tradable and non-tradable goods as well as differences between the financial cost of capital and its economic cost. These adjustments will be discussed later.

This chapter is organized as follows. Section 7.2 presents the three postulates underlying the methodology of economic valuation. Section 7.3 shows how these postulates are applied to the economic valuation of non-tradable goods and services when there are no distortions in their markets. Section 7.4 introduces the concept of distortions and their applications to the economic valuation of non-tradable goods and services. Section 7.5 briefly discusses a few other issues involving the three postulates. Concluding remarks are made in the last section.

7.2 Postulates Underlying the Economic Evaluation Methodology

The methodology adopted in this book to evaluate the economic benefits and costs of projects is built on the three postulates of applied welfare economics as summarized by Arnold Harberger.¹ These postulates in turn are based on a number of fundamental concepts of welfare economics.

- i) The competitive demand price for an incremental unit of a good or service measures its economic value to the demander and hence its economic benefit.
- ii) The competitive supply price for an incremental unit of a good or service measures its economic resource cost.
- iii) Costs and benefits are added up without regard to who the gainers and losers are. In other words, a dollar is valued at a dollar regardless of whether the benefit of the

¹ Harberger, A.C., "Three Basic Postulates for Applied Welfare Economics," *Journal of Economic Literature* IX, No. 3 (September 1971), pp. 785-797; and Harberger, A.C., "Reflections on Social Project Evaluation" in *Pioneers in Development*, Vol. II, edited by G.M. Meier, Washington: the World Bank and Oxford: Oxford University Press, (1987).

dollar accrues to a demander or a supplier, or to a high-income or a low-income individual.²

What is the implication of these postulates for the economic analysis of a project? When a project produces a good or a service (output), the economic benefit or the economic price of each incremental unit is measured by the demand price or the consumer's willingness to pay for that unit. These are firmly based on standard economic theory but they also involve certain subtleties and conditions. The demand curve represents the maximum willingness to pay for successive units of a good. As such, the demand curve reflects indifference on part of the consumer between having a particular unit of a good at that price and spending the money on other goods and services. As adjustments take place as a result of a project or other underlying event, the base assumption is that these are full adjustments over the whole economy. Individual prices and quantities may change in this and other markets, wages and incomes of different groups may rise or fall, but the economy is thought of as being always in equilibrium, with all markets being cleared.

The economic cost of a resource (input) that goes into the production of the project's output is measured by the supply price of each incremental unit of that resource. In other words, the economic cost of each incremental unit of an input is the price at which the supplier would just barely be willing to supply that unit. The supply curve is the locus of the successive minimum prices that suppliers are willing to accept for successive units of a good or service that they supply. These minimum prices represent the opportunity cost of these goods. Suppliers will be indifferent between selling these particular units of the good at their supply prices and using the inputs for alternative purposes. Again, adjustments along a supply curve take places in the context of the economy staying within its resource constraint, with equilibrium in all markets.

² This methodology can, however, be easily extended to allow for the benefits received by certain groups (e.g., the poor) to receive greater weight. The particular avenue that we follow to accomplish this goes under the label of base needs externalities and assigns special additional benefit values to projects that enhance the fulfillment of the basic needs of the poor.

Finally, the third postulate concerns the distributional aspects of a project and how they should be incorporated in the economic analysis of projects. By accepting each individual supplier's and demander's valuations and then taking the difference between total benefits and total costs, the basic methodology of applied welfare economics focuses on economic efficiency.³ The methodology in this book measures the net economic benefit of the project by subtracting the total resource costs used to produce the project's output from the total benefits of the output. In measuring the economic efficiency of projects, it adds up the dollar values of the net economic benefits regardless of who are the beneficiaries of the project.

The first step in moving beyond pure efficiency considerations consists of what is called stakeholder analysis, which simply breaks down the overall benefits and costs of a project into component pieces delineating the benefits and costs of particular institutions (business firms, banks, etc.) or groups (consumers, farmers, laborers, the poor, etc.) This is clearly an important part of an economic appraisal. To help us deal with these issues the chapter on stakeholder analysis contains a framework for identifying and measuring these distributive effects and offers some suggestions as to how this information may be included in the economic appraisal of a project.

7.3 Applying the Postulates to Determine Economic Evaluation of Non-Tradable Goods and Services in an Undistorted Market

In this section, we work through a number of simple examples to illustrate how economic costs and benefits of non-tradable goods and services in a project are estimated using these three postulates in undistorted markets.⁴ Distortions are defined in the context of this book to include taxes, subsidies, trade taxes, licenses and quotas, monopoly markups,

³ The approach with basic needs externalities can be used as an alternative to distributional weights. Details of the analysis can be found in Chapter 14.

⁴ A fuller explanation of the definition of a non-tradable is found in Chapter 11. At this point it is sufficient to consider a non-tradable as a good or service where there is no incentive for domestic suppliers to export the item or consumers to import the item. In this case the price of the item will be determined by the demand of local consumers interacting with the supply response of local suppliers.

environmental externalities, congestion costs or any other types of price or quantity restriction that causes the demand price of the item to diverge from its supply price.

Although one would be hard pressed to find a market without distortions, we nevertheless start the analysis in the context of non-distorted markets so as to present the methodology in its simplest form. This simple case demonstrates that a difference may exist between financial and economic prices even in the absence of distortions.

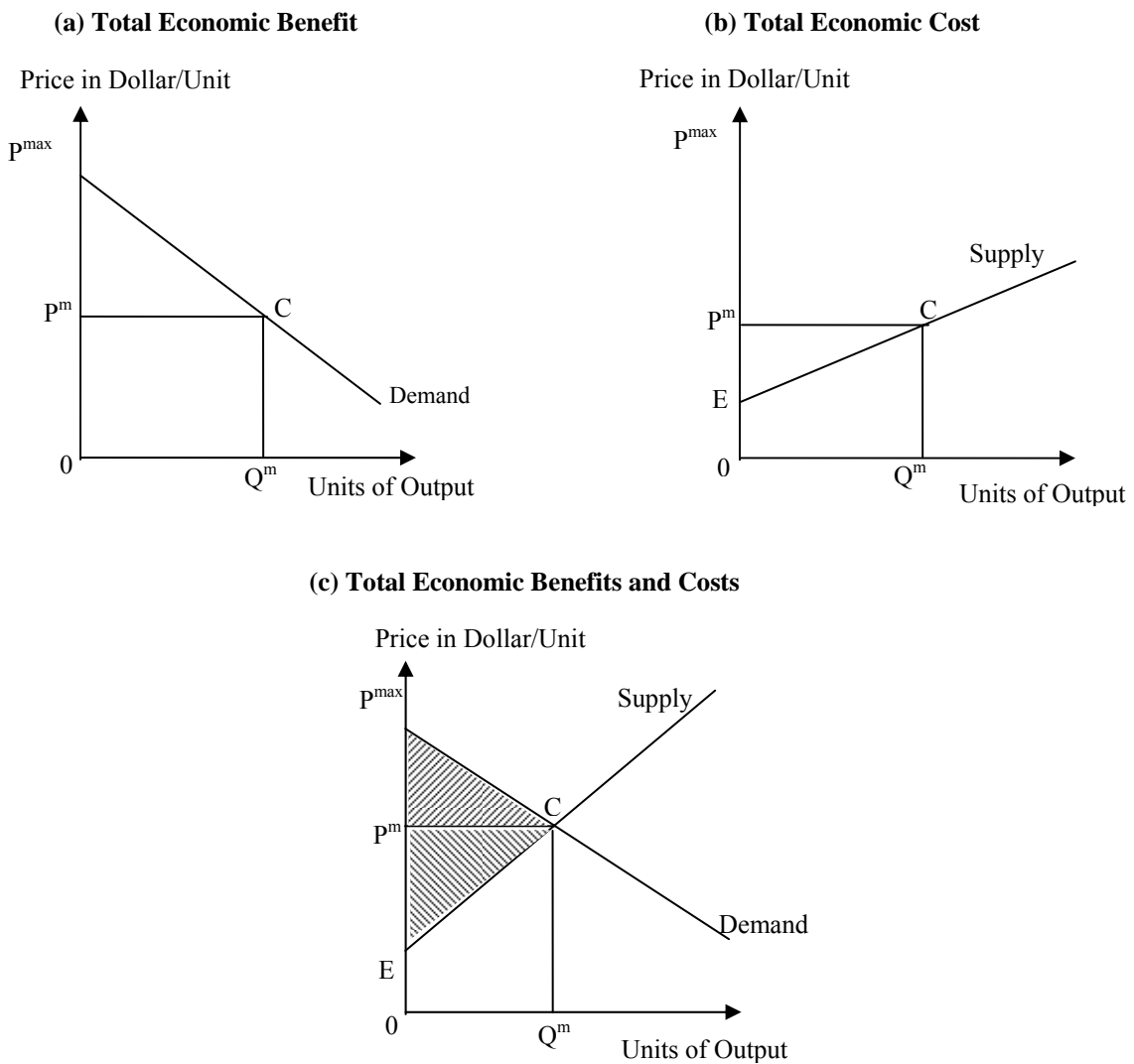
To understand the impact of a project's demand for an input on the market for that input, we start by analyzing that market. Similarly, to understand the impact of a project's output on the market for an output, we start by analyzing the market for that output. Consequently, we start our presentation below by developing a framework to show how the three postulates can be used to estimate economic costs and benefits in an existing market for a good or service (in the absence of a new project). We then proceed to show how the economic benefit of an output produced by a project can be estimated, and finally how the economic cost of an input used by a project is estimated.

7.3.1 Analyzing Economic Costs and Benefits in an Existing Market (in the absence of a new project)

Figure 7.1(a) presents the demand curve for a good in an undistorted market. The demand curve of a good shows the maximum price that consumers are willing to pay for successive units of the good. If the market-determined price of the good is P^m and the quantity consumed at that price is Q^m , then the economic benefit of the last (marginal) unit consumed is P^m but the benefits of earlier (inframarginal) units will be greater than P^m . The maximum benefit derived from the first unit consumed is P^{\max} as shown in Figure 7.1(a). Applying the first postulate, the benefits of the successive units consumed are determined by the corresponding prices on the demand curve. Consequently, the economic benefit of the output of this industry (the quantity Q^m) is given by the area $OP^{\max}CQ^m$.

Figure 7.1(b) presents the other side of the market, namely the supply side. The supply curve or marginal cost curve reflects the resource cost for producing successive units of the good. At the market-determined price P^m , the quantity Q^m is produced. While the resource cost of the marginal unit produced is P^m , that of each of the inframarginal units is less than P^m . Following the second postulate, the economic resource cost of producing Q^m is $OECQ^m$.

Figure 7.1: Economic Costs and Benefits in an Existing Market



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Figure 7.1(c) combines the demand and supply curves for this market. Following the third postulate, we add up the economic costs and benefits to determine the net gain or loss in this industry. Since the benefits are represented by the area $OP^{\max}CQ^m$ in Figure 7.1(a) and the costs are given by the area $OECQ^m$ in Figure 7.1(b), we have a net economic benefit given by the triangle $EP^{\max}C$ in Figure 7.1(c).

Although from this analysis, it is clear that the industry adding to the net wealth of the economy, we have not determined yet which group receives this net benefit of $EP^{\max}C$. To answer this question, let us return to Figure 7.1(c). The only price observable in the market is P^m and all Q^m units are bought and sold at this price. Consumers value each unit they consume at its corresponding price as given by the demand curve but they pay less than that price for all units consumed except the last one. This difference between what consumers value the output at and what they actually pay for it is a net gain to consumers and is known as consumer surplus. Consumers pay an amount equal to OP^mCQ^m but enjoy a gross benefit of $OP^{\max}CQ^m$. The amount of income saved by consumers because they are able to purchase all units at a price P^m is equal to the triangle $P^mP^{\max}C$ in Figure 7.1(c). This triangle is the consumer surplus.

The fact that all units are sold at a price P^m implies that industry revenues, OP^mCQ^m , are larger than the economic costs, $OECQ^m$. The excess of revenues over resource cost, the triangle in Figure 7.1(c) EP^mC , represents a net profit (over and above their normal or “required” rates of return or other supply prices) to the owners of the factors of production. This difference is known as economic rent or producer surplus. It now becomes evident that the net economic benefit in this industry as determined using the three postulates is shared between the owners of the production factors used in the industry and the consumers of its output.

The analysis above indicates that the gross economic benefits of the total output from this industry are greater than the financial revenues received by the suppliers in this industry - - the difference being the consumer surplus enjoyed by the consumers of the output. It also indicates that the economic cost of producing the output is less than the financial

revenues received by the suppliers -- the difference here being the producer surplus enjoyed by the suppliers. The implication of these two facts is that the financial prices of inframarginal units are typically different from their economic prices (i.e., the price of the last or marginal unit) even in the absence of distortions. This point is further addressed below.

7.3.2 Analyzing the Economic Benefits of an Output Produced by a Project

The previous analysis focused on an industry. In this section, we consider the more common case of a new project. Suppose our project produces a non-tradable good such as cement. Figure 7.2 shows the supply and demand for this non-tradable good. The industry demand and supply curves prior to the introduction of the new project are denoted by D_0 and S_0 , respectively. The new project produces a quantity Q_p and results in a shift in the industry supply curve from S_0 to S_{0+p} . The additional supply by the project results in a drop in the market price from P_0^m to P_1^m . As a result of the decrease in price, consumers demand more and total consumption increases from Q_0 to Q_1^d . Also due to the decline in price, existing suppliers will cut back their production from Q_0 to Q_1^s as some of them can no longer profitably supply the same amount of the good at the new (lower) price P_1^m . Q_p , the quantity produced by the project, equals the sum of the two quantities $Q_1^d - Q_0$ and $Q_0 - Q_1^s$.

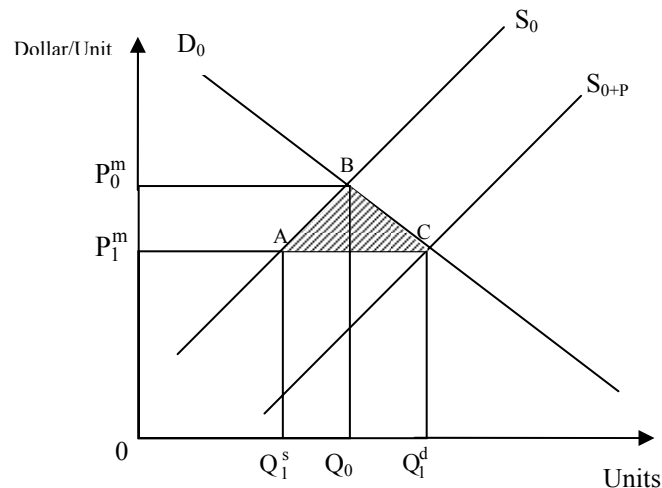
Since the project sells its output at the new prevailing market price P_1^m , the gross financial receipts to the project are given by $(Q_p \times P_1^m)$ which is area $Q_1^s A C Q_1^d$. To estimate the gross economic benefits of the project, we need to determine the economic value of the new consumption to the demanders, and the value of the resources released by existing suppliers. These values are estimated using the first two postulates as follows:

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- The additional consumption is valued, according to the first postulate, by the demand price for each successive unit, or by the area under the demand curve ($Q_0BCQ_1^d$).
- The resources released by other producers are valued, according to the second postulate, by the supply price (resource cost), along the “old” supply curve, not counting project output, of each successive unit or by the area under the supply curve ($Q_0BAQ_1^s$).

The gross economic benefits are given by the sum of the two areas above ($Q_1^sABCQ_1^d$). It is important to emphasize that these benefits are gross. In other words, we have not yet netted from them the economic costs of producing the project’s output. Saying that a project has positive gross economic benefits is the economic equivalent of saying that a project has positive gross financial receipts. The positive gross benefits alone do not indicate whether the project is economically viable or not, the same way that positive gross financial receipts do not indicate whether the project is financially profitable or not.

Figure 7.2: Economic Benefits of a New Project in an Undistorted Market



The gross benefits are equal to the sum of the financial receipts to the project’s owners ($Q_1^sACQ_1^d$), plus the gain in consumer surplus ($P_0^mBCP_1^m$), less the loss in producer

surplus (P_0^m BA P_1^m). In addition to the gross receipts to the project owners, consumers gain due to the reduction in price and producers lose economic rents due to the reduction in price. It is worth noting that the gross economic benefits exceed the financial receipts to the project's owners due to the net gain to consumers as the consumers' gain more than fully offsets the loss in economic rents to the existing producers.

It is often the case that the quantity produced by the project is relatively small compared to the size of the market, there will be only a small, but not zero, induced change in the market price. In such a situation and given that we are operating in an undistorted market, the gross financial receipts will be almost equal to the gross economic benefits. In other words, there is little difference between the financial revenues generated by a project and its economic benefits to the society. The difference will become significant only when the quantity produced by the project is sufficiently large to have a meaningful impact on the prevailing market price in the industry.

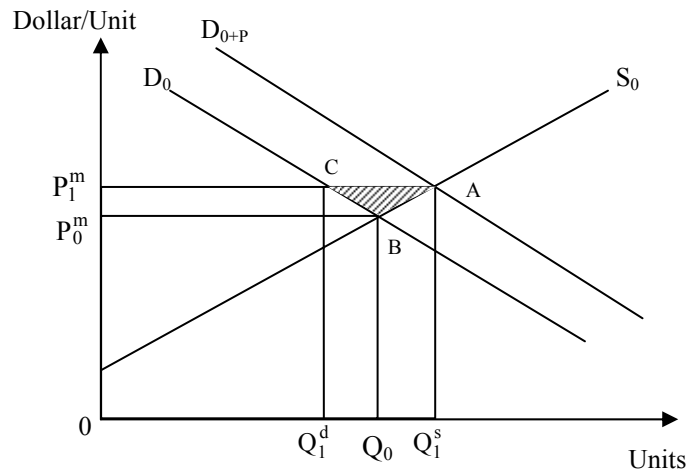
7.3.3 Analyzing the Economic Cost of an Input Demanded by a Project

The following example demonstrates how the economic cost of a non-tradable input demanded by a project can be estimated using the three postulates. The industry demand and supply curves without the additional demand by the new project are denoted by D_0 and S_0 , respectively (Figure 7.3). The new project demands a quantity Q_p and results in a shift in the industry demand curve from D_0 to D_{0+p} . The additional demand by the project results in a rise in the market price from P_0^m to P_1^m . As a result of the increase in price, existing consumers will cut back their consumption from Q_0 to Q_1^d and producers will increase their production from Q_0 to Q_1^s at the new (higher) price P_1^m . Q_p , the quantity demanded by the project, equals the sum of the two quantities $Q_0 - Q_1^d$ and $Q_1^s - Q_0$.

The project buys its requirement at the new prevailing market price P_1^m , and incurs a gross financial expenditure of $(Q_p \times P_1^m)$ which is the area Q_1^d CA Q_1^s . To estimate the

gross economic costs of the input demanded by the project, we need to determine the economic value of the consumption that is foregone by the existing consumers, and the value of the additional resources utilized to accommodate the project's demand. These values are estimated using the first two postulates as follows:

Figure 7.3: Economic Cost of an Input Demanded by a Project in an Undistorted Market



- The cutback in consumption is valued, according to the first postulate, by the demand price for each successive unit given up by other consumers -- the area under the demand curve ($Q_0BCQ_1^d$).
- The additional resources used to accommodate the expansion in output are valued, according to the second postulate, by the supply price (resource cost) of each successive unit -- the area under the supply curve ($Q_0BAQ_1^s$).

The gross economic cost for this input is given by the sum of the two areas above ($Q_1^dCBAQ_1^s$), which is equal to the financial cost to the project ($Q_1^dCAQ_1^s$), plus the loss in consumer surplus ($P_1^mCBP_0^m$), less the gain in producer surplus ($P_1^mABP_0^m$). Due to the increase in price brought about by the project's demand, existing consumers lose consumer surplus while producers gain economic rents. The economic cost per unit with the implementation of the project can be measured by $(P_0^m + P_1^m)/2$ with linear demand

and supply curves of any slope. However, it is worth noting that in this case, the gross economic cost is less than the financial cost paid by the project due to the fact that net gain to producers in economic rent exceeds the loss in consumer surplus to the existing consumers. The changes in consumer and producer surplus are a direct result of the price increase.

If the quantity demanded by the project is relatively small compared to the size of the market and there will be a very small change, but not zero, in the market price. In such a situation and given that we are operating in an undistorted market, the gross financial cost to the project will be virtually equal to the gross economic cost. In other words, the triangle difference between the financial cost paid by a project for an input and its economic cost to the society will be negligible. The difference will become important only when the quantity demanded by the project is sufficiently large to have a large impact on the prevailing market price in the industry.

By determining the economic cost of each input used by the project as outlined above, and the economic benefit of its output as presented above, we will be in a position to determine the economic viability of the project by subtracting all economic costs from the gross economic benefits.

7.4 Applying the Postulates to Determine Economic Evaluation of Non-Tradable Goods and Services in Distorted Markets

This section describes the impact of distortions on markets for goods and services whose domestic production satisfies all the domestic market demand for these items and whose domestic prices are not determined by their world prices. These are referred to as non-traded goods. In general, the markets for a project's outputs and inputs are distorted, where distortions are defined as market imperfections. The most common types of these distortions are in the form of government taxes and subsidies. Others include quantitative restrictions, price controls, and monopoly markups (the excess of price over marginal cost). In project appraisal, we take the type and level of distortions as given when

estimating the economic costs and benefits of projects. The task of the project analyst or economist is to select the projects that increase the country's net wealth, given the current and expected regime of distortions in the country.

While the presence of distortions in the markets of internationally non-tradables will render the estimation of the economic costs and benefits as well as the distributional impacts slightly more involved, the methodological framework is still entirely based on the three postulates of applied welfare economics. When dealing with undistorted markets in the examples above, the only difference between the financial receipts to the owners and the economic benefits was the gain in consumer surplus minus the loss in producer surplus. Similarly, the difference between the economic cost of the inputs used by the project, and the financial expenditures borne by the project owners, is the gain in producer surplus minus the loss in consumer surplus. In the absence of distortions, if a project causes a relatively small change in financial prices, the financial receipts from the sale of the output will be for all practical purpose equal to the gross economic benefits and the financial expenditures on the inputs will be similarly equal to their economic cost.

When a project produces an output in a distorted market, the market price will fall due to the increase in supply. Demanders will increase their demand while non-project suppliers will reduce their supply. This outcome is identical to the case of an undistorted market. The economic benefit of the project's output will be measured as the sum of the value of the additional demand measured by the demand price and the value of the additional resources measured by the supply price. Here again we see that the estimation process is similar to that of an output in an undistorted market.

7.4.1 Sales Taxes Levied on Output of Project

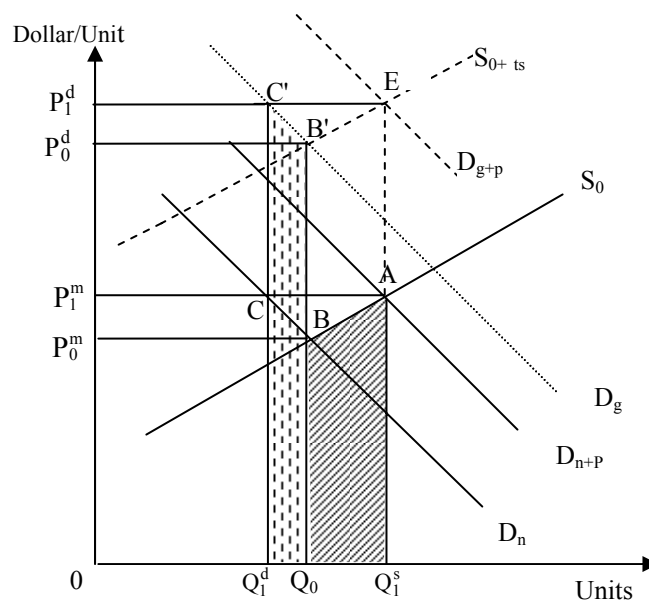
Taxes are imposed by governments primarily in order to raise revenues to pay for public sector expenditures.⁵ When a value added tax or a general sales tax (t_s) is imposed on an

⁵ Some theorists of public economics assert that the purpose of raising revenues is to enable the government to perform functions that cannot be undertaken by the private sector due to "market failures". They

internationally non-tradable, a divergence is created between their marginal value to consumers (P^d) that includes the sales tax, and the marginal cost of the resources used in production (P^s) that does not include the sales tax. In a situation when there is no other distortion on the supply of the item then the market price P^m will be equal to the marginal cost of production that is defined here as the supply price P^s . As a consequence in this situation $P^d = P^s (1 + t_s)$ or $P^d = P^m (1 + t_s)$

Let D_g denote the undistorted industry demand curve for an item as shown in Figure 7.4. This curve shows the value of each unit of the commodity to the demander or what the demanders are willing to pay. However, what they are willing to pay to suppliers (net of the tax) is given by D_n as shown in Figure 7.4. This is what suppliers will receive in order to cover their costs of production. The net of tax marginal cost of production is shown as the supply curve S_0 .

Figure 7.4: Economic Cost of an Input Demanded by a Project
 --- when a tax is imposed on sales ---



sometimes add that the government is also required to adopt appropriate fiscal and monetary policies for the stabilization of the economy. Finally, they and others often justify expenditures in social sectors (health care, education) as being necessary for reducing income disparities and promoting equity.

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Suppose a new project demands a quantity Q_p , causing the net of tax industry demand curve to shift from D_n to D_{n+p} . The additional demand by the project results in a rise in the net of tax market price from P_0^m to P_1^m . As a result of the increase in price, existing consumers who now must pay $P_1^d = P_1^m (1 + t_s)$ per unit will cut back their consumption from Q_0 to Q_1^d while producers will increase their production from Q_0 to Q_1^s , the quantity demanded by the project (Q_p) equals the sum of the two quantities $Q_0 - Q_1^d$ and $Q_1^s - Q_0$.

When the project buys its requirement, the effect is to shift the net-of-tax demand curve to the right by the amount $[(Q_1^s - Q_1^d) = Q_p]$ of project purchases, i.e., D_{n+p} . The gross of tax demand curve will also shift to D_{g+p} . The project will make a gross of tax financial expenditure of $Q_p * P_1^d (=Q_1^d C'E Q_1^s)$, but the suppliers of this input will get an amount equal to net of tax price times the quantity sold, $Q_p * P^m$ or $Q_1^d CA Q_1^s$, to cover their costs. However, we see that the producers of this item do not increase their production by the full amount of the additional demand. To estimate the gross economic costs of the input demanded by the project, we need to determine the economic value of the incremental consumption that is foregone by the existing consumers, and the value of the additional resources utilized to accommodate the project's demand. These values are estimated using the first two postulates as follows:

- The cutback in consumption is valued, according to the first postulate, by the demand price for each successive unit given up by other consumers -- the area under the demand curve inclusive of tax ($Q_1^d C'B'Q_0$). This is reflected by the gross of tax demand price P^d .
- The additional resources used to accommodate the expansion in output are valued, according to the second postulate, by the supply price (resource cost) of each successive unit -- the area under the supply curve ($Q_0 BA Q_1^s$). This is reflected by the net of tax supply price P^s or in this case the market price.

Thus, the economic cost of a project input can be measured by the sum of the supply price (P^s) times the change in quantity supplied (ΔQ^s) and the demand price (P^d) times the change in quantity demanded (ΔQ^d). That is:

$$P^e Q_p = P^s \Delta Q^s + P^d \Delta Q^d \quad (7.1)$$

where $Q_p = \Delta Q^s + \Delta Q^d$. The ratio of ΔQ^s and ΔQ^d to Q_p becomes the respective weight of supply and demand, w^s and w^d , as a consequence of the project demand for the good. One can also rewrite equation (7.1) and calculate the economic cost as the quantity demanded by the project input times the following expected economic price of the good (P^e):

$$P^e = w^s P^s + w^d P^d \quad (7.2)$$

The weights become an important factor in determining the economic price and, consequently, the economic cost of the good. These weights are generally determined by the own price elasticities of supply (ϵ) and demand (η) of the good, which reflect the responsiveness of the quantity supplied and demanded to a change in price of the good. They can be calculated below:

$$w^s = \epsilon / (\epsilon - \eta), \text{ and } w^d = -\eta / (\epsilon - \eta) \quad (7.3)$$

These elasticities refer to an average elasticity representing for the adjustments made by the market, as such they are long run elasticities of supply and demand. The relative share of demand and supply depends upon the market force of the specific good or service in question. With a longer timeframe, however, there tends to bring in more firms or producers in the supply process and thus providing a greater weight in supply unless there is a constraint in some of the production factors.

For example, suppose there is a greater response in the existing supply than demand in the economy to the project demand. Let us assume $w^s = 0.75$ and $w^d = 0.25$ with the

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market price and sales tax rate in which $P_0^m = \$90$, and $t_s = 0.15$. The economic price will then be calculated as:

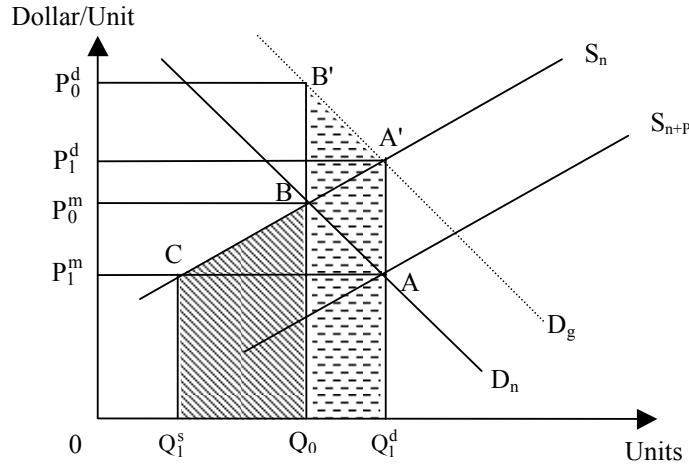
$$\begin{aligned} P^e &= w^s P^s + w^d P^d \\ &= 0.75 \cdot 90 + 0.25 \cdot [90 \cdot (1+0.15)] \\ &= \$93.375 \end{aligned}$$

If instead of project demanding this good as an input into its production, suppose we have a project that will increase the production of the good. The increase in project supply will shift the supply curve to the right from S_n to S_{n+p} as shown in Figure 7.5. The additional supply by the project results in a decrease in the net of tax market price from P_0^m to P_1^m . The fall in the market price will cause consumers to increase their demand from Q_0 to Q_1^d as the gross of tax demand price they pay falls from P_0^d to P_1^d . The decline in price received (net of tax) by producers of P_1^m will cause some of the existing producers to cut back their production from Q_0 to Q_1^s .

Since the project sells its output gross of tax at P_1^d but receives net of tax P_1^m , the gross financial receipts including taxes collected by the project are given by $(Q_p \times P_1^d)$ but the amount the project gets to keep net of taxes is shown by the area $Q_1^s CA Q_1^d$. However, the economic benefits produced by the project are measured by:

- For the incremental increase in consumption of $Q_1^d - Q_0$, the consumers' willingness to pay according to postulate one, is the gross of tax demand price. This is shown as the sum of the amount consumers are willing to pay the suppliers plus the increase in amount of taxes they are willing to pay to the government (the area BAA'B') for the additional consumption.
- The value of resources released, according to the second postulate, is measured by the supply price $P^s = P^m$ times the reduction in quantity supplied of $Q_0 - Q_1^s$. This is shown in Figure 5 as the area under the supply curve $Q_0BC Q_1^s$.

Figure 7.5: Economic Benefit of an Output Supplied by a Project
 --- when a tax is imposed on sales ---



For example, suppose $w^s = 2/3$, $w^d = 1/3$, $P_0^m = \$120$, and $t_s = 0.15$, then the economic price of the good is:

$$\begin{aligned} P^e &= w^s P^s + w^d P^d \\ &= 2/3 \cdot 120 + 1/3 \cdot [120 \cdot (1+0.15)] \\ &= \$126 \end{aligned}$$

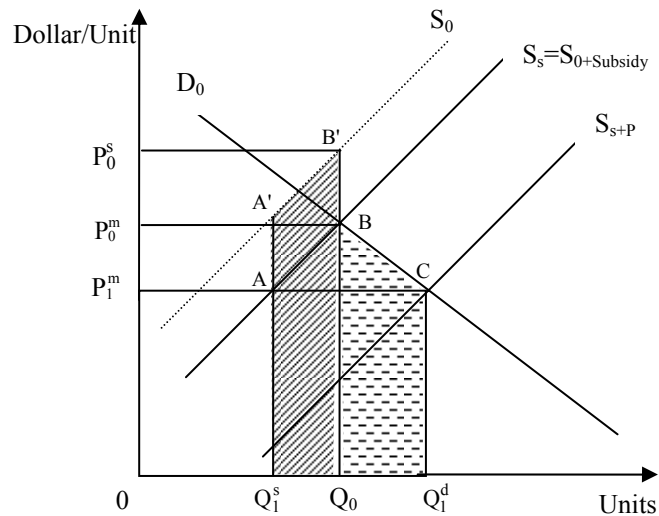
In this case when the change in the market price is small, the net economic benefits are greater than the financial benefits by the amount of additional tax revenue collected by the government. The additional tax accruing to the government will depend on the size of the tax rate and the incremental increase in the total supply of the good sold in the market as a consequence of the project.

7.4.2 Subsidies on Production

When a government wants to encourage the production of a non-tradable good, it may subsidize private producers to increase their output of the good or service. Figure 7.6 shows that the industry demand and supply curves in the absence of distortions prior to the introduction of the new project are denoted by D_0 and S_0 , respectively. With a unit

subsidy where the government gives the producer a fixed amount per unit sold, the market supply curve will shift downward to the curve denoted by $S_s (= S_{0+subsidy})$. Now suppose a new project produces a quantity Q_p , equal to $(Q_1^d - Q_1^s)$, that causes the industry supply to shift curve from S_s to S_{s+p} . The additional supply by the project results in a movement of the market price from P_0^m to P_1^m . As a result of the decrease in price, consumers increase the quantity demanded and total consumption increases from Q_0 to Q_1^d . Also due to the decline in price, existing suppliers will cut back their production from Q_0 to Q_1^s as they will no longer supply the same amount of the good at the lower price P_1^m . The quantity produced by the project, Q_p , equals the sum of the two quantities $Q_1^d - Q_0$ and $Q_0 - Q_1^s$.

**Figure 7.6: Economic Benefits of a Project
-- when a production subsidy is present --**



Since the project sells its output at the new prevailing market price P_1^m ,⁶ the gross financial receipts to the project are given by $(Q_p \times P_1^m)$ which is area $Q_1^s AC Q_1^d$. To estimate the gross economic benefits of the project, we need to determine the economic

⁶ Here we assume the project does not get the subsidy. However, the economic value of the project output is the same whether or not the project output receives the subsidy.

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value of the additional new consumption to the demanders, and the value of the resources released by existing suppliers. These values are estimated using the first two postulates as follows:

- The additional consumption is valued, according to the first postulate, by the demand price for each successive unit -- the area under the demand curve ($Q_0BCQ_1^d$).
- The resources released by other producers are valued, according to the second postulate, by the supply price (resource cost) of each successive unit -- the area under the supply curve without subsidy ($Q_1^sA'B'Q_0$). This area includes the amount of production cost that was being paid for by consumers through the item's sales price and the amount of reduction in government subsidy shown by the area ($AA'B'B$).

Subsidy may be expressed as either a percentage of the market price or a proportion of total production cost. In this example, suppose subsidy is given at 40 percent of resources (k) spent on production of the good and we also assume the responsiveness of the existing supply and demand to the change in price as a result of the project output as follows: $w^s = 1/3$, $w^d = 2/3$, $P_0^m = \$90$, and $k = 0.40$, then the economic price of the good can be calculated as:

$$\begin{aligned} P^e &= w^s P^s + w^d P^d \\ &= 1/3 \cdot [90/(1-0.40)] + 2/3 \cdot 90 \\ &= \$110 \end{aligned}$$

With the introduction of distortions in the form of taxes and subsidies, another stakeholder enters the picture in the form of the government. When there are other externalities created by pollution, monopoly markups, price controls, the project will affect other groups in society. Consequently, when estimating the economic costs and benefits of goods and services in these distorted markets, we may expect additional

benefits or costs and new players added to the list of beneficiaries or losers affected by the project.

The three basic postulates can also be used to determine the economic values for tradable goods and foreign exchange. These situations are treated in detail in later chapters.

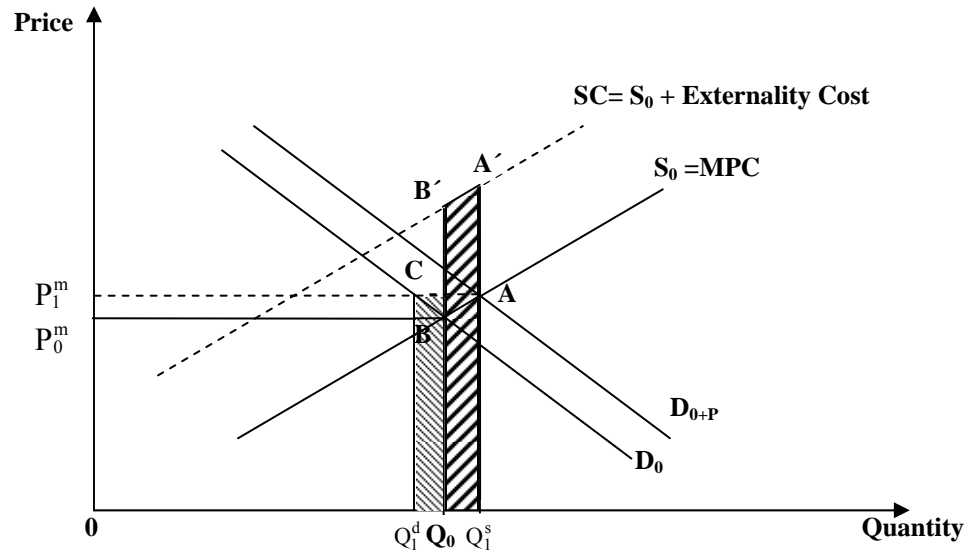
7.4.3 Environmental Externalities

Suppose pollution is being created by an industry that is producing an input for our project. For example, some firms create waste products or effluents that are deposited in the atmosphere, waterways and on the ground. This has a damaging effect on people and properties that are not directly involved with the production or consumption of the output. Assume resources will have to be used now or at some future date to deal with this environmental damage. These are resource costs that are not recognized by the consumers of the industry's output in the financial price of the item must be included in the economic cost.

Let D_0 and S_0 denote the industry demand and supply curve of the good. If the impact on the environment is not completely internalized in the private production costs, then the damage caused by the external impact of the pollution should be estimated and added to the input cost to the project as shown in Figure 7.7.

Suppose the project demands the good as project input and causes the demand curve to shift from D_0 to D_{0+p} . As a result, the market price rises from P_0^m to P_1^m . The total consumption will decrease from Q_0 to Q_1^d and other existing suppliers will expand their production from Q_0 to Q_1^s . Q_p , the quantity produced by the project, equals the sum of the two quantities $Q_0 - Q_1^d$ and $Q_1^s - Q_0$.

Figure 7.7: A Project Buy an Input with a Pollution Externality



In this case, the gross financial costs to the project are given by $(Q_p \times P_1^m)$ which is shown by the area $Q_1^s AC Q_1^d$. The gross economic costs of the project are determined by the economic value of the foregone consumption by some demanders, and the value of the resources increased by other existing suppliers plus the additional pollution cost. These values are estimated using the first two postulates as follows:

- The reduced consumption is valued, according to the first postulate, by the demand price for each successive unit -- the area under the demand curve ($Q_0 BC Q_1^d$).
- The additional resources demanded by producers alone are valued by the area under the supply curve as $Q_0 BA Q_1^s$. However, the total economic cost of production must also include the polluter externality of $BB'A'A$, yielding a total economic cost for $Q_0 Q_1^s$ of $Q_1^s A'B'Q_0$.

In this case the economic cost of the project's input is greater than its financial cost to the project.

On the other hand, there are projects that may reduce the level of production of other producers who pollute the air or water. In this case, the project will create a positive externality due to a reduction of the adverse impact on environment of the other producers who now cut back their level of output.

In any event, the evaluation of environment impacts may not be always straightforward and will often require a special environmental impact study. It may be noted that infrastructure projects as well as natural resource extraction and energy projects produce a great variety of environmental externalities including atmospheric emissions (sulfur, nitrogen and carbon gases) that damage the forests and eco-systems. These environmental externalities are real, and genuinely impinge costs on the well-being of people within a country. Hence these economic costs should be included as part of the economic costs of a project.

7.5 Other Distortions

There are other distortions in an economy to which the principles of the three basic postulates also apply. Important areas where other distortions play a significant role in causing divergences between economic and financial prices are the economic opportunity cost of capital (invested in the project) and the economic cost of workers employed in the project. They are briefly discussed in this section.

7.5.1 The Economic Opportunity Cost of Capital

Different approaches have been used to determine the economic cost of capital. However, economic analysis suggests that the most plausible and widely applicable approach is to postulate that new expenditures are “sourced” in the capital market, and that the normal destination of “free” funds is that they are returned to the capital market. In a small and open economy, this “sourcing” comes from three places. These sources are a) displaced investment (i.e., resources that would have been invested in other investment activities

but are either displaced or postponed by our project's extraction of funds from the capital market), b) newly stimulated saving (as economic agents respond to increased interest rates), and c) additional foreign capital inflows (as foreign suppliers of funds also respond to the same stimulus).

Based on these three alternative sources of public funds, the economic cost of capital can be estimated as a weighted average of the rate of return on displaced or postponed investments, the rate of time preference applicable to those who make additional savings and the marginal cost of additional foreign capital inflows. In general, various distortions are associated with each of the three alternative sources of funds. The methodology will be described in detail in Chapter 8.

7.5.2 The Economic Opportunity Cost of Labor

In the labor market there are a variety of factors that may create a divergence between the market wage and the economic cost of a worker at the project. This cost of employment, referred to as the supply price of labor, reflects the whole panoply of the market and non-market incentives facing workers as they consider the options of being in the work force or not, and once they are there, as they consider all the monetary and non-monetary factors that govern the desirability of working at our project vis-à-vis those many alternative options these workers face. It will also take into account any tax differential that a worker may face as a result of moving to the project from another employment.

Sometimes the project is expected to pay net wages that are higher than the supply price of labor in the market. This is mostly true when there are minimum wage laws or unionized labor. One can also find other reasons why some employers offer wages that exceed the prevailing market rates. In all such cases, a wedge is created between the wage actually paid to workers in a project and the cost incurred by the economy when such workers are employed on a project.

Whereas in calculating the economic cost of capital or foreign exchange, we are dealing with a fairly homogeneous item, virtually the opposite is true in the case of labor. Wages differ by occupation, skill, experience, location, type of job, etc. We will be fully conscious of this extreme heterogeneity when we estimate the economic prices of different categories of labor in Chapter 12.

7.6 Conclusion

This chapter has presented the three postulates underlying the methodology of economic evaluation. We have first shown how the three postulates are applied to the economic valuation of non-tradable goods and services in an undistorted market and later how they apply when distortions are present.

In general, there will likely be many distortions prevailing in an economy under evaluation. These distortions include among others, value added taxes, excise duties, import duties, and production subsidies.

Later chapters will give detailed explanations of how distortions of various kinds enter into the estimation of the economic opportunity costs of foreign exchange, of capital, and of labor of different types, as well as of specific inputs and outputs, both tradable and nontradable. We hope that the present chapter has given readers a useful overview, a point of departure for the more detailed analyses to come.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 8:**

THE ECONOMIC OPPORTUNITY COST OF CAPITAL

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ABSTRACT

An investment project usually lasts for many years, hence its appraisal requires a comparison of the costs and benefits over its entire life. For acceptance, the present value of the project's expected benefits should exceed the present value of its expected costs. Among a set of mutually exclusive projects, the one with the highest net present value (NPV) should be chosen. This criterion requires the use of a discount rate in order to be able to compare the benefits and costs that are distributed over the life of the investment. The discount rate recommended here for the calculation of the economic NPV of projects is the economic opportunity cost of capital for the country. If the economic NPV of a project is greater than zero, it is potentially worthwhile to implement the project. This implies that the project would generate more net economic benefits than the same resources would have generated if used elsewhere in the economy. On the other hand, if the NPV is less than zero, the project should be rejected on the grounds that the resources invested would have yielded a higher economic return if they had been left for the capital market to allocate them to other uses. This chapter explains how the economic opportunity cost of funds to an economy is derived and how it is used in the appraisal of an investment to calculate its economic present value.

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CHAPTER 8

THE ECONOMIC OPPORTUNITY COST OF CAPITAL

8.1 Why is the Economic Cost of Capital Important?

An investment project usually lasts for many years, hence its appraisal requires a comparison of the costs and benefits over its entire life. For acceptance, the present value of the project's expected benefits should exceed the present value of its expected costs. Among a set of mutually exclusive projects, the one with the highest net present value (NPV) should be chosen.¹ This criterion requires the use of a discount rate in order to be able to compare the benefits and costs that are distributed over the life of the investment.

The discount rate recommended here for the calculation of the economic NPV of projects is the economic opportunity cost of capital for the country. If the economic NPV of a project is greater than zero, it is potentially worthwhile to implement the project. This implies that the project would generate more net economic benefits than the same resources would have generated if used elsewhere in the economy. On the other hand, if the NPV is less than zero, the project should be rejected on the grounds that the resources invested would have yielded a higher economic return if they had been left for the capital market to allocate them to other uses.

In the process of project design the economic cost of capital also plays an important role in the maximization of the potential economic NPV of a project. It is a critical parameter for decision making relating to the optimum size of the project and the appropriate timing for the implementation of an investment. Both are key factors affecting the project's net benefits and its ultimate feasibility. In addition, the choice of technology for a project is influenced by the opportunity cost of capital. For example, a low cost of capital will

¹ The benefit cost ratio is often used as a decision criterion in an economic evaluation. However, the NPV criterion is known to be more reliable than other criteria for both the financial and economic evaluation. For the financial appraisal, other criteria include the payback period, the debt service ratio, and the internal rate of return. Each of these criteria has its own shortcomings. Detailed discussions are presented in Chapter 4.

encourage the use of capital-intensive technologies as opposed to labor- or fuel- intensive technologies.

(a) Choosing the Scale of a Project

An important decision in project appraisal concerns the size or scale at which a facility should be built. It is seldom that the scale of a project is constrained by technological factors, hence economic considerations should be paramount in selecting its appropriate scale. Even if the project is not built to its correct size, it may be a viable project because its NPV may still be positive, but less than its potential. The NPV is maximized only when the optimum scale is chosen.

As was discussed in Chapter 5, the appropriate principle to use for determining the scale of a project is to treat (hypothetically, and on the drawing board, as it were) each incremental change in size as a project in itself. An increase in the scale of a project will require additional expenditures and will generate additional benefits. The present value of the costs and benefits of each incremental change should be calculated by using the economic discount rate.

The NPV of each incremental project indicates by how much it increases or decreases the overall net present value of the project. This procedure is repeated (at the planning, drawing board stage) until a scale is reached where the net present value of incremental benefits and costs associated with an increment of scale changes from positive to negative. When this occurs, the previous scale (with the last upward step of NPV) is the optimum size of the plant. The effect that the economic opportunity cost of capital or economic discount rate has on determining the size of the net present value gives it a central role in the determination of the optimum scale of a project.

(b) Timing of Investment

Another important decision to be made in project analysis relates to the appropriate time for a project to start. A project that is built too soon could result in a large amount of idle capacity. In this case, the forgone return from the use of resources elsewhere might be

larger than the benefits gained in the first few years of the project's life. On the other hand, if the project is delayed too long, shortages may occur and the forgone benefits of the project will be greater than the alternative yields of the resources.

Whenever the project is undertaken too early or too late, its net present value will be lower than what it could have been if developed at the right time. The net present value may still be positive, but it will not be at the project's potential maximum.

The key to making a decision on this issue is whether the costs of postponement of the project are greater or smaller than the benefits of postponement. In the easiest case, where investment costs K remain the same whether the project is started in either periods t or $t+1$, the costs of postponement from year t to year $t+1$ are simply the economic benefits B_{t+1} forgone by delaying the project. On the other hand, the benefit of postponement is the economic return (r_e) that can be earned from the capital invested in the general economy. Thus the benefit from postponement is equal to the economic opportunity cost of capital multiplied by the capital costs (i.e., $r_e \times K_t$).² One can see again that the value for the economic opportunity cost of funds is an essential component for deciding the correct time for starting the project.³

(c) Choice of Technology

In order to be worthwhile undertaking, any investment project must earn enough to cover the economic opportunity cost of capital. If this is not so, the capital would better be left to be allocated to other uses through the normal working of the capital market.

Sometimes public sector projects face a financial cost of capital that is artificially low. This is true not only when they can raise funds at an artificially low rate of interest because of government subsidies or guarantees. It is even true (typically) when they raise

² There are a number of cases where the benefits and capital costs are also a function of calendar time. They are discussed in Chapter 5.

³ This exercise applies when the benefits of the project in period t are the same, regardless of whether the investment was made in t , $t+1$, $t+2$, etc. and also that the stream of project benefits over time is increasing with time, i.e., $B_{t+2} > B_{t+1} > B_t$.

funds at the market-determined rate of yield in government bonds. In either case, the cost of capital perceived by the project may be far below its economic opportunity cost.

The use of a lower financial cost of capital instead of its economic opportunity cost would create an incentive for the project managers to use production techniques that are too capital intensive. The choice of an excessively capital-intensive technology would lead to economic inefficiency because the value of the marginal product of capital in this activity is below the economic cost of capital to the country. For example, in electricity generation, using a financial cost of capital that is lower than its economic cost will make capital-intensive options such as distant hydroelectric dams or nuclear power plants more attractive than oil- or coal-fired generation plants.⁴ A correct measure of the economic opportunity cost of capital is, therefore, necessary for making the right choice of technology.

8.2 Alternate Methods for Choosing Discount Rates for Public Sector Project Evaluation

The choice of the discount rate to be used in economic cost benefit analysis has been one of the most contentious and controversial issues in this area of economics. The term “discount rate” refers to the time value of the costs and benefits from the viewpoint of society. It is similar to the concept of the private opportunity cost of capital used to discount a stream of net cash flows of an investment project, but the implications can be more complex. However, after much debate a consensus, or at least a reasonably good understanding of the issues, has emerged.

There have been basically four alternative approaches put forth on this issue. First, some authors have suggested that all investment projects, both public and private, should be discounted by a rate equal to the marginal productivity of capital in the private sector.⁵

⁴ Jenkins, G.P., “Public Utility Finance and Economic Waste”, *Canadian Journal of Economics*, (August 1985).

⁵ Hirshleifer, J., DeHaven, J.C. and Milliman, J.W., *Water Supply: Economics, Technology, and Policy*, Chicago: University of Chicago Press, (1960).

The rationale for this choice is that if the government wants to maximize the country's output, then it should always invest in the projects which have the highest return. If private sector projects have a higher expected economic return than the available public sector projects, then the government should see to it that funds are invested in the private rather than public projects.

Secondly, authors such as Little and Mirrlees, and Van der Tak and Squire have recommended the use of an accounting rate of interest.⁶ Their accounting rate of interest is the estimated marginal return from public sector projects given the fixed amount of investment funds available to the government. The accounting rate of interest is essentially a rationing device. If more projects look acceptable than available investible funds, the accounting rate of interest should be adjusted upwards; and if too few projects look promising, the adjustment should go the other way. Therefore, the accounting rate of interest does not serve to ensure that funds are optimally allocated between the public and private sectors but acts only to ensure that the best public sector projects are recommended within the constraint of the amount of funds available to the public sector. This approach does not recognize the fact that if the funds are not spent by the public sector, they can always be used to reduce the public sector's debt. They will then be allocated by the capital market for the use by the private sector.

Thirdly, it has been recommended that the benefits and costs of projects should be discounted by the social rate of time preference for consumption, but only after costs have been adjusted by the shadow price of investment to reflect the fact that forgone private investment has a higher social return than present consumption. This method has been proposed by such authors as Dasgupta, Sen, Marglin and Feldstein.⁷

⁶ Little, I.M.D. and Mirrlees, J.A., *Project Appraisal and Planning for Developing Countries*, London: Heinemann Educational Books Ltd., (1974); Squire, L. and van der Tak, H.G., *Economic Analysis of Projects*, Baltimore: The Johns Hopkins University Press, (1975).

⁷ Dasgupta, P., Sen, A. and Marglin, S., *Guidelines for Project Evaluation*, Vienna: United Nations Industrial Development Organization, (1972); Marglin, S., "The Social Rate of Discount and the Optimal Rate of Investment", *Quarterly Journal of Economics*, (February 1963); Feldstein, M., "The Social Time Preference Discount Rate in Cost-Benefit Analysis", *Economic Journal*, 74, (June 1964).

Fourthly, Harberger and other authors have suggested that the discount rate for capital investments should be the economic opportunity cost of funds obtained from the capital market. This rate is a weighted average of the marginal productivity of capital in the private sector and the rate of time preference for consumption.⁸ This proposal has been reinforced by the theoretical work of Sandmo and Dreze⁹ and reconciled to a degree with the alternative approach of using a social rate of time preference in conjunction with a shadow price of investment by Sjaastad and Wisecarver.¹⁰

Many professionals have chosen to follow this weighted average opportunity cost of funds concept. Furthermore, Burgess has shown that under a wide range of circumstances the use of the economic opportunity cost of funds as the discount rate, leads to the correct investment choice, while other approaches lead to the selection of inferior projects.¹¹

In its simplest form the economic opportunity cost of public funds (i_e) is a weighted average of the rate of time preference for consumption (r) and the rate of return on private investment (ρ). It can be written as follows:

$$i_e = W r + (1 - W) \times \rho \quad (8.1)$$

⁸ Harberger, A.C., "On Measuring the Social Opportunity Cost of Public Funds", in *The Discount Rate in Public Investment Evaluation*, Report No. 17, Conference Proceedings from the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Denver Colorado, (December 1968) and Harberger, A.C., "Reflections on Social Project Evaluation", in *Pioneers in Development*, Vol. II, edited by G.M. Meier, Washington: The World Bank and Oxford: Oxford University Press, (1987).

⁹ Sandmo, A., and Dreze, J.H., "Discount Rates for Public Investment in Closed and Open Economies", *Economics* 38, (November 1971); Dreze, J.H., "Discount Rates and Public Investment: A Post-Scriptum", *Economics* 41, No. 161 (February 1974).

¹⁰ Sjaastad, L.A. and Wisecarver, D., "The Social Cost of Public Finance", *Journal of Political Economy* 85 No. 3 (May 1977).

¹¹ Burgess, D.F., "Removing Some Dissonance from the Social Discount Rate Debate", University of Western Ontario, London, Ontario, Canada (June 2006).

where W_c is the proportion of the incremental public sector funds obtained at the expense of current consumption and $(1-W_c)$ is the proportion obtained at the expense of postponed investment.¹²

8.3 Derivation of the Economic Opportunity Cost of Capital

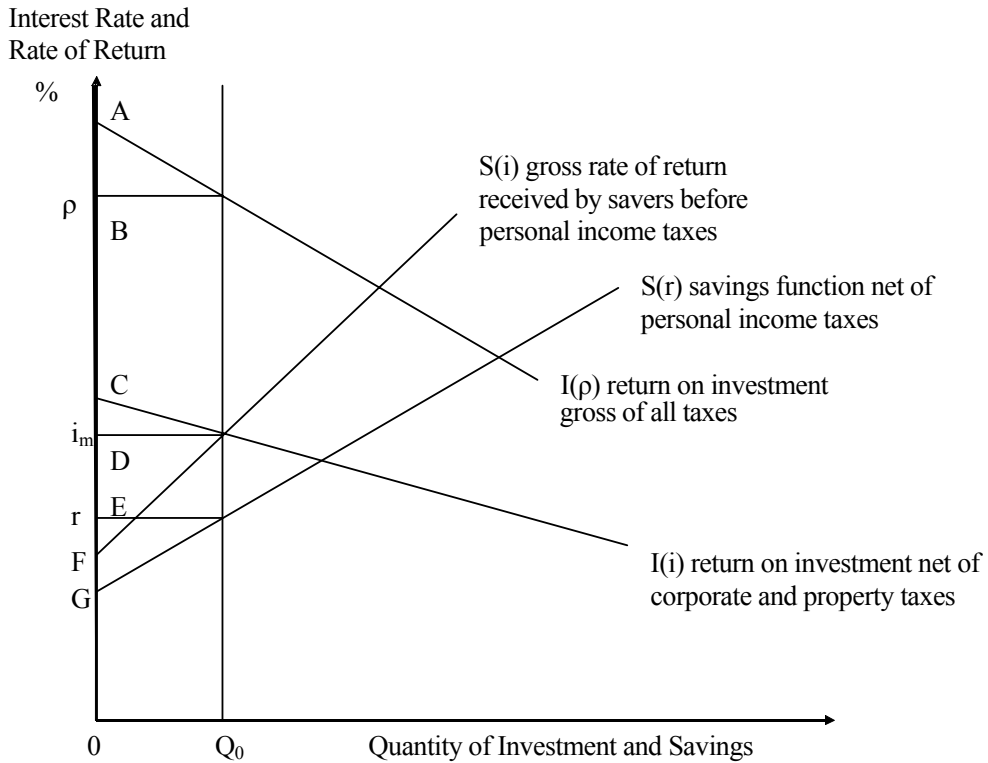
The rates of interest observed in the capital markets are fundamentally determined by the willingness of people to save and the opportunities that are available for investment. In an economy characterized by perfect competition with full employment and no distortions, the real market interest rate would reflect the marginal valuation of capital over time and could be used as the economic discount rate. However, in reality there are distortions in the capital markets, such as business and personal taxes, and inflation, hence, market interest rates will neither reflect the saver's time preferences for consumption nor the gross economic returns generated by private sector investment. Both savers and investors must take into consideration taxes and other distortions when entering the capital market to lend or borrow.

The determination of the market interest rate can be illustrated in Figure 8.1 for the case where savers are required to pay personal income taxes on interest income and borrowers pay both business income taxes and property taxes from the investment. For the moment, the effects of inflation will be set aside so that all the rates of return are expressed in real terms. The curve $GS(r)$ shows the relationship between the supply of savings and the rate of return (r) received from savings net of personal income taxes. This function tells us the minimum net return savers must receive before they are willing to postpone current consumption and save for future consumption. If there is a personal income tax, then savers will require a return sufficiently larger than r to allow them to pay income taxes on

¹² For a more complete discussion of this derivation, see Harberger, A.C., "On Measuring the Social Opportunity Cost of Public Funds", in *The Discount Rate in Public Investment Evaluation*, Report No. 17, Conference Proceedings from the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Denver Colorado, (December 1968) and Harberger, A.C., "Professor Arrow on the Social Discount Rate" in *Project Evaluation*, Chicago: University of Chicago Press, (1972).

the interest income and still have a return of r left. The savings function which includes the taxes on interest income is shown as $FS(i)$.

Figure 8.1 Determination of Market Interest Rates



At the same time, investors have a ranking of investment projects according to their expected gross of tax rates of return which is shown as the curve $AI(\rho)$. If the owners of the capital have to pay property taxes and business income taxes, they will be willing to pay less for their investment funds than in a no-tax situation. $CI(i)$ reflects the rate of return investors can expect to receive net of all business and property taxes. In this market situation the interest rate (i_m) will be determined by the gross-of-personal-income-tax savings function $FS(i)$ and the net-of-tax demand for investment curve $CI(i)$.

The basic principle which must be followed to ensure that a project's investment expenditures do not ultimately retard the level of the country's economic output is that such investments must produce a rate of return at least equal to the economic return of other investment and consumption that is postponed, plus the true marginal cost of any additional funds borrowed from abroad as a direct or indirect consequence of this project. To form a general criterion for the economic opportunity cost of capital for a country, we must assess the sources from which that capital is extracted and attach an appropriate economic cost to each source.

For most countries, it is realistic to assume that there exists a functioning capital market. That is not to say that it is free of distortions, for it is the existence of distortions such as taxes and subsidies which prevents us from using the real interest rate in the market as a measure of the economic opportunity cost of funds. In addition, most governments and private investors obtain marginal funds to finance their budgets from the capital market, and during periods of budgetary surplus typically reduce their debts.

It is true that the financing for a government's budget comes from many sources other than borrowing, such as sales and income taxes, tariffs, fees, and perhaps sales of goods and services. The average economic opportunity cost of all these sources of finance combined may well be lower than the economic opportunity cost of borrowing. This fact is irrelevant, however, for the purpose of estimating the marginal opportunity cost of the government's expenditures. As in estimating the supply price of any other good or service, the marginal economic opportunity cost must reflect the ways in which an incremental demand will normally be met. Even in the very short run most governments are either borrowing or, when enjoying a budgetary surplus, paying off some of their debt.¹³ Therefore, if fewer public sector projects are undertaken in a given year, more funds will be available in the capital markets for private sector use.

We do not wish to imply that every government uses each year the capital market as its source or repository of marginal funds. However, the overwhelming evidence from

observing developing and developed countries indicates that this is a fair characterization of the behavior of most governments. As the economic discount rate is a parameter which should be generally applicable across projects and estimated consistently over time, it is prudent for a country to base its estimation of the economic opportunity cost on the cost of extracting the necessary funds from the capital market. The approach has a further advantage in that the capital market is clearly the marginal source of funds for most of the private sector. Hence, it follows that the economic opportunity cost of funds for both the public and private sectors are based on the costs derived from similar capital market operations.

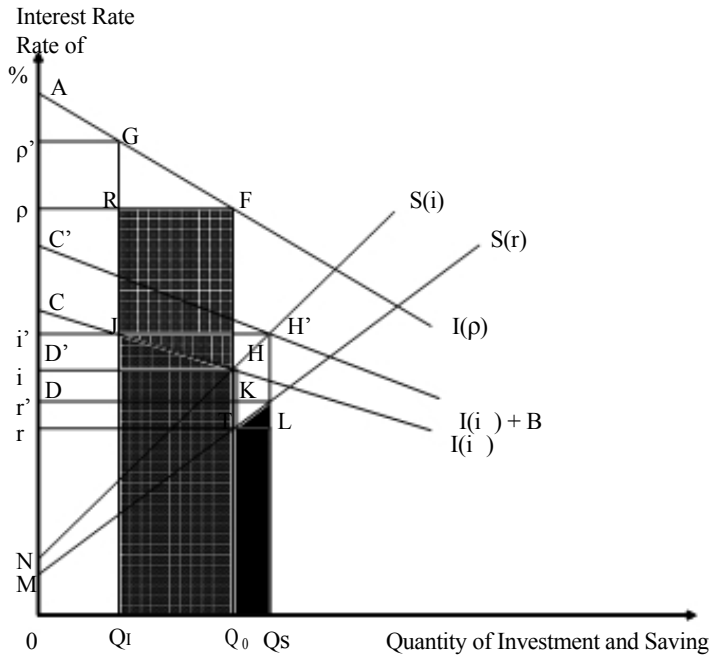
To estimate the economic opportunity cost of funds obtained via the capital market, we will first assume that the country's capital market is closed to foreign borrowing or lending. It is also assumed that taxes such as property taxes and business income taxes are levied on the income generated by capital in at least some of the sectors. In addition, we assume that a personal income tax is applied to the investment income of savers.

In Figure 8.2, we begin with a situation where the market rate of return is i_m , and the quantity of funds demanded and supplied in the capital market is Q_0 . At this point, the marginal economic rate of return on additional investment in the economy is ρ and the rate of time preference which measures the marginal value of current consumption is equal to r . We now borrow funds in the amount of B from the capital market to finance our project by the amount of $(Q_s - Q_1)$. This causes the total demand in the economy for loanable funds to shift from $CI(i)$ to $C'I(i)+B$. However, the value of funds for investment elsewhere in the economy, and the net of tax returns to them, is measured by the curve $CI(i)$. The gross of tax return on the investments is measured by the curve $AI(\rho)$.

The increase in the demand for funds by the project will cause the market cost of funds to increase from i to i' , thus inducing people to save more (postpone consumption) by an amount $(Q_s - Q_0)$. At the same time, the higher cost of funds will cause people to postpone investments by an amount $(Q_0 - Q_1)$.

¹³ Some of this debt may reflect foreign as well as domestic borrowings.

Figure 8.2 The Economic Opportunity Cost of Capital



The economic cost of postponing consumption is equal to the area Q_0TLQ_s , which is the net of tax return savers receive from their increased savings. This is measured by the area under the $MS(r)$ curve between Q_0 and Q_s . With a linear supply function this area estimated by the average economic cost per unit, $[(r + r')/2]$, times the number of units, $(Q_s - Q_0)$. Postponed investment has a gross of tax economic opportunity cost which is measured by the $AI(\rho)$ curve. This includes both the net return given up by the private owners of the investment measured by the curve $CI(i)$, plus the property and business taxes lost. This opportunity cost is shown by the shaded area Q_1GFQ_0 , of which Q_1JHQ_0 is the net return forgone by the would-be owners of the investment, and $JGFH$ represents the amount of taxes lost by the government. Again, this can be calculated by the economic opportunity cost per unit $[(\rho + \rho')/2]$ times the number of units $(Q_0 - Q_1)$. For marginal changes in government borrowing, we can safely disregard the triangles RGF and KLT which arise from the change in interest rates.

The economic opportunity cost of capital i_c can then be defined as:

$$i_e = \frac{r \times (\partial S / \partial i) - \rho \times (\partial I / \partial i)}{(\partial S / \partial i) - (\partial I / \partial i)} \quad (8.2)$$

where $(\partial S / \partial i)$ and $(\partial I / \partial i)$ denote the reaction of savers and other investors, respectively, to a change in market interest rates brought about by the increase in government borrowing.

Expressed in elasticity form, equation (8.2) becomes:

$$i_e = \frac{r \times \varepsilon_s - \rho \times \eta_I \times (I_T / S_T)}{\varepsilon_s - \eta_I \times (I_T / S_T)} \quad (8.3)$$

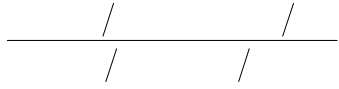
where ε_s is the elasticity of supply of private-sector savings, η_I is the elasticity of demand for private-sector investment with respect to changes in the rate of interest, and I_T / S_T is the ratio of total private-sector investment to total savings.

Let us suppose that $\rho = 0.16$ and $r = 0.05$. Also let us assume that $\varepsilon_s = 0.3$, $\eta_I = -1.0$ and $I_T / S_T = 0.9$. In this case the economic opportunity cost of capital can be calculated as:

$$\begin{aligned} i_e &= [0.05 (0.3) - 0.16 (-1.0) (0.9)] / [0.3 - (-1.0)(0.9)] \\ &= (0.015 + 0.144) / (1.20) \\ &= 0.133 \end{aligned}$$

The economic opportunity cost of capital is 13.3%. Typically, it will be closer to the gross return from investment than the rate of time preference on consumption because the elasticity of private savings is generally much smaller than the absolute value of the elasticity of demand for private-sector investment.

In equation (8.3), all the different groups of savers have been aggregated into one category, and all groups of investors have also been grouped into one sector. The



aggregate elasticity of supply of savings and the aggregate elasticity of demand for investment can be disaggregated into their components as follows:

$$\varepsilon^s = \sum_{i=1}^m \varepsilon_{is} (S_i / S_T) \quad (8.4)$$

$$\eta^I = \sum_{j=1}^n \eta_{jI} (I_j / I_T) \quad (8.5)$$

where ε_{is} refers to the elasticity of supply of the i th group of savers, and (S_i/S_T) is the proportion of total savings supplied by this group; η_{jI} refers to the elasticity of demand for the j th group of investors, and (I_j/I_T) is the proportion of the total investment demanded by this group.

Substituting equations (8.4) and (8.5) into equation (8.3), we obtain an expression for the economic opportunity cost of capital which allows for consideration of different distortions within the classes of savers and investors:

$$i_e = \frac{\sum_{i=1}^m \varepsilon_{is} (S_i / S_T) r_i - \sum_{j=1}^n \eta_{jI} (I_j / I_T) \rho_j}{\sum_{i=1}^m \varepsilon_{is} (S_i / S_T) - \sum_{j=1}^n \eta_{jI} (I_j / I_T)} \quad (8.6)$$

The classes of savers will usually be differentiated by income groups which face different marginal income tax rates. There is also saving done by domestic businesses. However, it is not clear if higher interest rates would affect the amount of business saving because the decisions businessmen make whether to pay or not dividends is based more on business investment opportunities. Thus the amount of business saving is assumed in this study to be independent of interest rates. We can also include in the broad class of savers the foreign savers which supply the funds to the country when it sources funds from abroad. As the international capital markets become more accessible to domestic investors, we

would expect the elasticity of supply of this sector to increase relative to the other sources of savings. In some circumstances, we may even find that the cost of foreign borrowing and the elasticity of supply foreign savings might dominate the entire equation (8.6). It is therefore important to properly assess the economic cost of foreign borrowing which will be discussed in Section 8.5.

On the demand side, investors are typically divided into the corporate sector, the noncorporate sector, housing, and agriculture, according to the different tax treatment provided to these sectors.

8.4 Determination of the Economic Cost of Alternative Sources of Funds

Measuring the real rate of return to reproducible capital in a country is not an easy task. In most cases the most consistent approach is based on the country's national income accounts. At the very least, the accounts presume to cover the full range of economic activities in the country (including such items, for example, the implicit income from owner-occupied houses, and the value added of many informal sector activities).

Employing this method of calculation, one starts from a past base period, and the real amount of investment made during each period from the base year until the present. For these purposes, the amounts of real investment should be obtained by deflating nominal investment by the general GDP deflator (not the official investment deflator). The purpose of this is to express the capital stock of the country in the same units of account as are used to express the earnings of capital. Our methodology employs the GDP deflator as the general numeraire; it is used to convert all nominal values into real values.

If investment is available by component, it is desirable to carry out the estimations component by component (buildings, machinery, vehicles, inventories), so as to allow for different depreciation rates on these categories. Once an initial capital stock K_{j0} is estimated for each component, and its appropriate depreciation rate δ_j established, the

time path of the capital stock is generated by the formula $K_{j,t+1} = K_{jt}(1 - \delta_j) + I_{jt}$ where I_{jt} denotes the amount of new gross investment for each component.

Obviously, one cannot speak of a separate rate of return to different pieces of the capital stock of the same entity, so we express the rate of return as Y_{kt}/K_t , where $K_t = \sum K_{jt}$ and Y_{kt} is the income from capital at time t . It consists of the sum of interest, rent and profit income, as recorded in the national accounts. If these items do not appear explicitly, one usually can at least find a breakdown that includes wages and salaries as one category, corporate profits as a second, and the surplus of non-corporate enterprises as a third. Here the challenge is to separate the surplus of non-corporate enterprises into two components; one representing the value added due to time value of the owners and their family members, the other representing the gross return to capital in these enterprises.

This does not complete the task, however. For certain, since we are building up a stock of K_t of reproducible capital, its value should necessarily exclude that of land (improvement to land, like fences, canals, even leveling, should, however, be treated as reproducible). So from the income stream accruing to capital we definitely want to exclude the portion that we estimate as accruing to land. Also we should exclude most elements of government capital from the capital base we use to calculate its rate of return. Likewise, we should exclude from the relevant “return to capital” any income from these items. In some countries, this would give us a rate of return straightforwardly based on the “real earnings of reproducible private-sector capital” (in the numerator) and the “real value of this private-sector capital stock” (in denominator). In most countries, however, these also exist in public sector productive entities like electricity companies, railroads, airlines, ports, and even manufacturing facilities that behave sufficiently like other business enterprises to warrant their being counted in the same calculation, alongside private business enterprises.

To see clearly the motive for this treatment, readers should focus on the purpose for which we want to calculate the economic opportunity cost of capital in the first place. That purpose is best seen by visualizing the exercise of anybody -- a private company,

one or more individuals, a non-profit institution, the government itself -- going into the country's capital market to raise money. This puts added pressure on that market, and squeezes out other demanders for funds, while giving some additional stimulus to suppliers of funds in that market. We take the position that the actions of business firms and private savers are governed by natural economic motives, in the sense that we can take seriously in their case, the idea that they have reasonably well-defined supply and/or demand functions for funds as a function of interest rates and other variables in that country's capital market. We feel that government (apart from those public enterprises that really behave like business firms) operates mainly with a different type of machinery -- legislative acts and authorizations, budgetary decisions, administrative edicts and the like. In short, we do not see previously authorized public investments being "naturally" squeezed out by a tightening capital market, in the same way as we see this same phenomenon for regular business investments.

Our vision of the economic opportunity cost of capital is that as new demands for funds in a country's capital market squeeze out alternative investments, the country loses (a perhaps better forgoes) the returns that would have been generated by these investments; at the same time, the country incurs the costs involved in covering the supply prices of the new amounts of saving that are stimulated by the new demand, plus whatever incremental costs are entailed in newly-generated capital inflows from abroad.

We thus start with a weighted average of the marginal productivity (ρ) of displaced investments, the marginal supply price (r) of newly-stimulated savings and the marginal cost (MC_f) associated with newly-stimulated inflows from abroad. This simple vision can be represented as:

$$EOCK = f_1\rho + f_2 r + f_3 (MC_f) \quad (8.7)$$

where f_1 , f_2 , and f_3 are the sourcing fractions linked, respectively, with sourcing from displaced investment, newly stimulated domestic savings, and newly stimulated capital inflows from abroad. Obviously $f_1 + f_2 + f_3$ should equal one.

A key element in this story is ρ , since f_1 is typically the largest of the three sourcing fractions. As mentioned, we conceive of ρ as representing the typical marginal productivity of the class of investments it is meant to cover. We recommend its estimation, as indicated above, on the basis of the ratio of “returns to reproducible capital (net of depreciation but gross of taxes) in the productive sector of the economy” divided by “value of reproducible capital in the productive sector of the economy”. If the reproducible capital stock can be conveniently estimated only for the total economy, then we would advise reducing this stock by a fraction that one estimates would account for the bulk of public sector capital items -- government buildings, schools, roads, etc. that are not basically business-oriented.

To get the rate of return that represents the supply price (r) of newly stimulated domestic savings, we must certainly exclude the taxes on income from capital that are paid directly by business entities, plus the property taxes paid by these entities as well as by homeowners. In addition, we would want to exclude the personal income taxes that are paid on the basis of the income from reproducible capital.

If one works with aggregate national accounts data, we would recommend subtracting from the gross-of-tax return to reproducible capital the full amount of corporation income taxes paid and the full amount of property taxes paid, adjusted downward to exclude an estimated portion falling on land. In addition, one needs to subtract the full amount of personal income taxes paid on the income from capital, also adjusted downward to exclude the income taxes that are paid on the income derived from land.

When this is done the remaining value covers not only the net-of-tax income received by individual owners of capital, but also the costs of intermediation -- easiest understood (in the case of bank loans) as the difference between the average rate of interest the banks receive on their loans and the average rate that they pay to their depositors.

It is possible also to approach the estimation of the economic opportunity cost of capital in a more disaggregated way; distinguishing separate categories of displaced investment

(e.g., corporate, non-corporate and housing) owing to different tax treatments they receive, and distinguishing different categories of savings on a similar basis (e.g., savers with marginal tax rates of 30, 20, 10, and zero percent). For example, in the latter case the higher is the individuals' rate of personal income tax the lower will be the person's equilibrium rate of time preference for consumption. In a situation where the market interest rate is equal to 0.08 and the marginal rate of personal income tax is assumed at 0.1, the value for r is 0.072. Now consider a high income individual who is faced with a marginal personal income tax rate of 0.4. In this case the rich will have low rates of time preference at 0.048 in their decisions of how to spend their consumption over time. Thus, high rates of time preference and high discount rates correspond more closely to the decisions of the poor concerning the distribution of their consumption over time.

Furthermore, consumers who are borrowing in order to finance current consumption will typically have higher rates of time preference than people who only save. If the margin required by finance companies and money lenders over the normal market interest rate is M percentage points, then the rate of time preference for borrowers for consumer loans is the sum of the market interest rate and M percentage points. Suppose M is 0.11, then the rate of time preference for borrowers for consumer loans becomes 0.19, a rate which is often charged on credit cards, even in advanced countries. From these examples we can see that as we move from the poor borrowers to the rich groups in society which are net savers, the time preference rate can quite realistically fall from 0.19 to 0.048.

However, we feel that this approach, which we ourselves have often used in the past,¹⁴ suffers from its de-linking to the aggregate national accounts framework. For example, our preferred framework deducts taxes actually paid, and thus incorporates all the effects of avoidance, evasion and corruption as they live and breathe in the country in question,

¹⁴ Jenkins, G.P., "The Measurement of Rates of return and Taxation from Private Capital in Canada", in W.A. Niskanen et al., eds., *Benefit-Cost and Policy Analysis*, Chicago: Aldine, (1973) ; and Barreix, A., "Rate of Return, Taxation, and the Economic Cost of Capital in Uruguay", a Ph. D. dissertation submitted to Harvard University, Cambridge, Cambridge, (2003). In the case by Barreix, the analysis is done using both aggregate and sector-disaggregated approaches and then shows that both estimates were completely reconcilable.

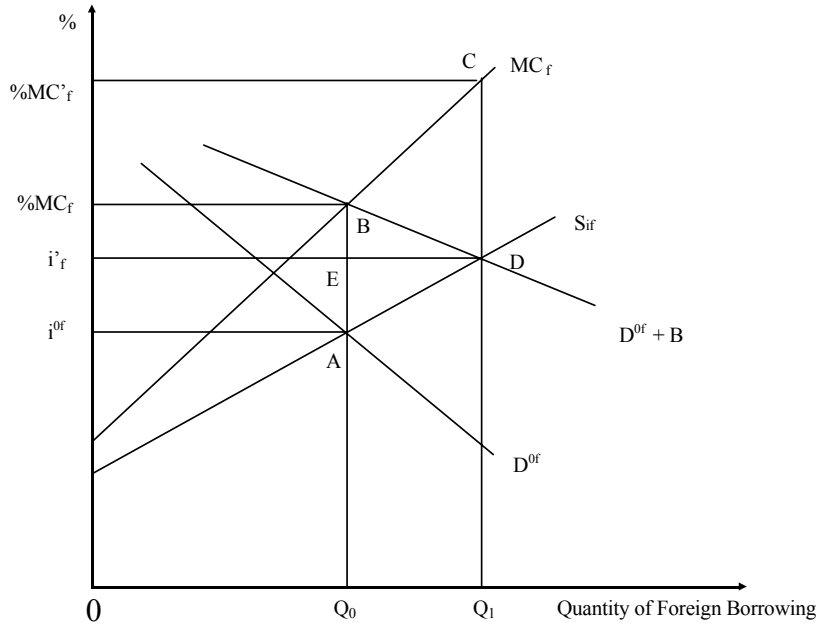
while the disaggregated framework tends, perhaps naively, to make the assumption that the statutory marginal rates are rigorously applied.

8.5 Marginal Economic Cost of Foreign Financing

In this section, we deal with the estimation of marginal economic cost of newly-stimulated capital inflows from abroad as a result of project funds raised in capital markets. Foreign capital inflows reflect an inflow of savings of foreigners which augments the resources available for investment. When the demand for investible funds is increased, this will not only induce domestic residents to consume less and save more, but it will also attract foreign saving. When the market interest rate is increased to attract funds, an additional cost is created in the case of foreign borrowing. This higher interest rate is paid not only on the incremental borrowing but will also be charged on all the variable interest rate debt both current and prior, which are made on a variable interest rate basis. Thus, it is the marginal cost of borrowing by the project that is material in this case.¹⁵

If the interest rate on foreign borrowing by the project is i'_f , it only reflects the average cost of this financing. The marginal cost that is relevant is given by the sum of the cost of foreign financing of the additional unit and the extra financial burden on all other borrowings that are responsive to the market interest rate. This is shown in Figure 8.3.

¹⁵ Harberger, A., "Vignettes on the World Capital Market", *American Economic Review*, Vol. 70, No. 2, (May 1980); Edwards, S., "Country Risk, Foreign Borrowing, and the Social Discount Rate in an Open Economy", *Journal of International Money and Finance*, (1986).

Figure 8.3 The Marginal Economic Cost of Foreign Borrowing

If a country faces an upward sloping supply curve for foreign financing, the interest rate which borrowers have to pay will increase as the quantity of debt rises relative to the country's capacity to service this foreign debt. With a demand curve for foreign borrowing shown as D^{of} the interest rate charged on such loans is shown at i^{of} and the quantity of foreign borrowings Q_0 . Now suppose the demand for loanable funds (B) increases such that its demand for foreign loans shifts to $D^{of} + B$. As a result of the additional funds ($Q_1 - Q_0$) demanded in the capital market, there will be a slightly higher market interest rate (i'_f) paid to foreign savers. This higher interest rate i'_f will be paid not only on the foreign borrowing of this year but on any variable interest rate loans in its stock of foreign financing which are affected by the increased market interest rate for foreign financing. The latter also includes the country risk for the country. With the greater stock of foreign financing that must be serviced using foreign exchange, the lender faces a greater exposure to the risk of default from macroeconomic instability. As a consequence, the marginal economic cost of foreign borrowing (MC_f) is not given by the

supply curve of foreign savings available to the country, but by the marginal economic cost curve which lies above the supply curve.

Algebraically, the marginal economic cost of foreign borrowing is shown as:

$$MC_f = i_f \times (1 - t_w) + (\partial i_f / \partial L) \times (1 - t_w) \times \phi \times L \quad (8.8)$$

where t_w : the rate of withholding taxes charged on interest payments made abroad;

L : total value of the stock of foreign financing;

ϕ : the ratio of [the total foreign debt whose interest rate is flexible and will respond to additional foreign financing] to [the total stock of foreign financing for the country]; and

$\partial i_f / \partial L$: rate of change in the cost of foreign financing as the current foreign financing increases.

Or alternatively,

$$MC_f = i_f \times (1 - t_w) \left\{ 1 + \phi \times \left(\frac{1}{\varepsilon_s} \right) \right\} \quad (8.9)$$

where ε_f is the supply elasticity of foreign funds to a country with respect to the cost of funds the country pays on its new foreign financing.

Let us consider the case where $i_f = 0.10$, $t_w = 0.20$, $\varepsilon_f = 1.5$, $\phi = 0.60$. Using equation (8.9), MC_f is equal to 0.112. In this case with a market interest rate of 10 percent for foreign loans, the marginal cost for foreign borrowing would be 11.2 percent.

A final factor which needs to be considered when estimating the marginal economic cost of foreign borrowing is the effect of the expected rate of inflation. If gp_f denotes the

expected rate of foreign inflation, then the marginal economic cost of foreign borrowing (MC'_f), after adjustment for inflation, can be derived as follows:

$$MC'_f = \frac{[i_f \times (1 - t_w) - gp_f] \times [1 + \frac{1}{\phi \times \frac{1}{\epsilon_{sf}}}]}{(1 + gp_f)} \quad (8.10)$$

To estimate the economic opportunity cost of capital in an open economy, we need to combine equation (8.7) with equation (8.10) and the estimate of gross-of-tax return from domestic investment (ρ) and the cost of newly stimulated domestic savings (r). It is these rates of opportunity cost along with their respective weights that generate the weighted average rate which should be used as the rate of discount for all government expenditures.

8.6 Inter-Generational and Risk-Adjusted Economic Discounting

Questions have been raised whether a lower rate should be used for inter-generational discounting because many of the people affected by some project or policy may no longer be alive over the distant future.¹⁶ However, there is little consensus in the economic literature on economic discounting for inter-generational projects or policies. There are several reasons for not favoring the use of different discount rates over the project impact period unless the opportunity cost of funds is abnormally high or low from one period to another.

¹⁶ E.g., United States Environmental Protection Agency, Guidelines for Preparing Economic Analyses, (September 2000).

Second, for projects in which capital expenditures are incurred at the beginning of the project while benefits are spread over the life of the project applying one discount rate for the streams of costs and another for the streams of benefits can be tricky and empirically difficult for each project. The informational requirements are very demanding for converting all the streams of costs into consumption equivalents in a consistent manner. The problem becomes more complicated when the stream of costs and benefits occur simultaneously and are spread over all years. Using a weighted average of the economic rate of return on alternative sources of funds, the discount rate based on the opportunity cost of forgone investment and consumption can avoid the complicated adjustments.

A risk-adjusted economic discount rate has also been suggested elsewhere to account for the systematic risk of future uncertainty.¹⁷ However, the discount rates derived above are associated with the average risk in the economy. Since the streams of uncertain future costs and benefits are mainly related to the input variables themselves, they are best dealt with in the Monte Carlo risk analysis as described in Chapter 6 rather than the adjusted economic discount rates.

¹⁷ E.g., Brean, D.J.S., Burgess, D.F., Hirshhorn, R. and Schulman, J., "Treatment of Private and Public Charges for Capital in a Full-Cost Accounting of Transportation", Report Prepared for Transportation Canada, Government of Canada, (March 2005).

8.7 Country Study: Economic Cost of Capital for South Africa

This section illustrates how the economic opportunity cost of capital for South Africa is estimated following the methodology outlined in the previous sections. South Africa is considered a small open developing economy. When funds are raised in the capital market to finance any investment projects those funds are likely to come from three alternative sources as described in Section 8.4. They are funds released from displaced or postponed investment, newly stimulated domestic savings, and newly stimulated foreign capital inflows. Following equation (8.7), the economic opportunity cost of capital can be estimated by the sum of multiplying the opportunity cost of each of the three alternative sources of funds by the shares of the funds diverted from each of these sources.

8.7.1 Estimation of the Economic Cost of the Three Diverted Funds

(a) Gross-of-Tax Return to Domestic Investment

Using the approach based on the national income and expenditure accounts, the return to domestic investment can be estimated from the GDP net of depreciation and the contributions made by labor, land, resource rents, and the associated sales and excise taxes. The total contribution of labor to the economy is the sum of wages and salaries paid by corporations and by unincorporated businesses. Since owners of unincorporated businesses are also workers but are often not paid with wages, the operating surplus of this sector thus includes the returns to both capital and labor. The labor content of this mixed income was estimated at 35% for South Africa during the period between 1995 and 1999.¹⁸ The 35 percent figure is used and assumed throughout the period from 1985 to 2004.

Land is a fixed factor of production that makes a contribution to value added especially in the agriculture and housing sectors. The contribution of land in the agricultural sector is

¹⁸ This figure was obtained from officials of South African Reserve Bank in Pretoria.

assumed to be one-third of the total value added in that sector.¹⁹ Regarding the housing sector, information is not available on the amount of value added produced by this sector nor is it available for the value added of the land component for the sector. Hence this component is not incorporated in the calculation.

In South Africa resource rents arise due to the fact that in the past the mining of nonrenewable resources such as gold, coal, platinum and diamonds have made a substantial contribution to GDP. These specific resources are non-renewable; when exploited with the help of reproducible capital, they can yield substantial economic resource rents.²⁰ These resource rents should be subtracted from the income to capital in order to derive the income to reproducible capital.

Moreover, it should be noted that the value-added tax implemented in South Africa is a consumption-type tax and allows a full credit for the purchase of capital goods. Hence, the value-added tax is effectively borne by the value added of labor and not capital, hence it should be subtracted from GDP in order to derive the return to capital alone.

To arrive at a rate of return, the value of the income attributed to the stock of reproducible capital is then divided by the total estimated value of the reproducible capital stock reduced by the value of the reproducible capital stock attributed to production of general government services. Over the past 15 years, the average real rate of return on investment

¹⁹ Data are not available for the agricultural sector alone, but available on a combined basis for agriculture, forestry and fishing. Because of the importance of agriculture in South Africa, it is assumed that the value added in the agricultural sector accounts for 95 percent of the total value added in the agricultural, forestry and fishing sector combined. Further, the assumption that the contribution of land set equal to one-third of the total value added of the agricultural is consistent with what has been estimated in countries of a similar level of development.

²⁰ The resource rents were estimated by Blignaut, J.N. and Hassan, R.M., "A natural Resource Accounting Analysis of the Contribution of Mineral Resources to Sustainable Development in South Africa", *South African Journal of Economic and Management Sciences*, SS No. 3, (April 2001). However, the resource rents shown here are calculated based on the assumption that the real rate of return to the reproducible capital in mining is 10 percent real for the period from 1985 to 1993. From year 1994, the resource rents are assumed to increase with inflation rate due to absence of data for these years.

in South Africa is estimated to be approximately 12.73% as shown in Appendix 8.1.²¹ The value of ρ is thus taken to be 13.0 percent for this exercise.

(b) *The Cost of Newly Stimulated Domestic Savings*

When project funds are raised in the capital markets, it will stimulate domestic savings in banks or other financial institutions. The net-of-tax return to the newly stimulated domestic savings can be measured by the gross-of-tax return to reproducible capital minus the amount of income and property taxes paid by corporations and the personal income taxes paid by individuals on their income from investments. It is further reduced by the cost of the financial intermediation services provided by banks and other financial institutions. These costs of financial intermediation are an economic resource cost that increases the spread between the time preference rate for consumption and the interest rate charged to borrowers. Due to lack of detailed data in this sector, it is estimated by assuming that the value added produced by financial institutions accounts for one half of the value added created by the total of all financial institutions and real estate combined. Furthermore the intermediation services are estimated as a further half of the value added in the financial institutions.²² The amount of return then divided by reproducible capital stock represents the net rate of return to households on newly stimulated savings. It also reflects the rate of time preference for forgone consumption.

Using national accounts data over the past 20 years, the cost of newly stimulated domestic savings (r) for South Africa is estimated at about 4.50 percent as shown in Appendix 8.2.

(c) *Marginal Economic Cost of Foreign Financing*

²¹ This estimate is lower than the one shown in Kuo, C.Y., Jenkins, G.P., and Mphahlele, M.B., “The economic Opportunity Cost of Capital in South Africa”, *South African Journal of Economics*, (September 2003) for the following reasons. First, the amount of return to capital in the Kuo-Jenkins-Mphahlele study was measured gross of depreciation and the reproducible capital stock was assumed the total stock in the economy including those of general government services. Second, the national accounts data appear to have been revised substantially in some areas especially since 1995.

²² See Statistics South Africa, Final Supply and Use Tables, 1998. The fraction of value added in the financial institutions was about 48 percent of those in the financial institutions, real estates, and business activities combined. The share of operating surplus in total value added in financial institutions was 53 percent.

The real marginal cost of foreign financing (MC_f) can be estimated by using equation (8.10). In South Africa, long-term debts currently account for more than 70 percent of total foreign debt. These long-term debts are mostly dominated in U.S. dollars. The coupon rate charged by the U.S. institutions ranges from 8.375 percent to 9.125 percent for U.S. dollar bonds.²³ For this exercise, it is assumed that the average borrowing rate from abroad is about 8.5 percent per annum with the GDP deflator of 2.5 percent in the U.S.

The fraction of long term loans outstanding with variable interest rates, ϕ , is about one-third.²⁴ If we include both long and short term debts with variable interest rates they would amount to 53 percent of the total stock of South Africa's foreign debt. For the purpose of this exercise, it is assumed to be about 50 percent. Thus the following information is given: $i_f = 8.5\%$, $t_w = 0$, $gp_f = 2.50\%$, and $\phi = 0.50$. With the assumption of 1.5 for ε_f , one can obtain the value of MC'_f that is approximately 7.80 percent.

8.7.2 Weights of the Three Diverted Funds

The weights of the three diverted funds depend upon the initial shares of the sources of these funds and their price responsiveness to changes in the market interest rates. We estimate that the average ratio of the total private-sector investment to savings (I_T/S_T) for the past 20 year is about 73%. The average shares of total private-sector savings are assumed to be approximately 20% for households, 65% for businesses and 15% for foreigners.²⁵ With the assumptions of the supply elasticity of household saving at 0.5, the supply elasticity of business saving at zero,²⁶ the supply elasticity of foreign funds at 1.5 and the demand elasticity for private sector capital in response to changes in the cost of funds at -1.0, one can estimate the proportions of each of the diverted funds. They are

²³ South African Reserve Bank, *Quarterly Bulletin*, (June 2006)

²⁴ The percentage of long term debts with variable interest rate declined from 69.9 percent in 1994 to 33.8 percent in 1999. See the World Bank, *Global Development Finance*, (2001).

²⁵ These shares fluctuate from year to year in South Africa. It is also a parameter for sensitivity analysis. ²⁶ It is not clear if higher interest rates would affect the amount of business savings. This is because businesses are more concerned with investment opportunity.

9.48 percent from newly stimulated domestic savings, 21.33 percent from newly stimulated foreign capital, and 69.19 percent from displaced or postponed domestic investment.

8.7.3 Estimates of the Economic Cost of Capital

The economic opportunity cost of capital can be estimated as a weighted average of the rate of return on displaced private-sector investment and the rate of return to domestic and foreign savings. Substituting the above data into equation (8.7), one can obtain an estimate of the economic cost of capital for South Africa of 11.08 percent.

The empirical results depend on the values of several key parameters such as the supply elasticity of foreign capital, the initial share of each sector in total private-sector savings, the average rate of return on domestic investment, resource rents, the labor content of mixed capital-labor income for unincorporated businesses, foreign inflation rate, etc. A sensitivity analysis is performed to determine how robust the estimate of the economic cost of capital is. The results indicate that the value would range from 10.74 percent to 11.49 percent.²⁷ Thus, a conservative estimate of the economic cost of capital in South Africa would be a real rate of 11 percent.

8.8 Conclusion

The discount rate used in the economic analysis of investments is a key variable in applying the net present value or benefit-cost criteria for investment decision making. Such a discount rate is equally applicable to the economic evaluation, as distinct from a financial analysis, of both private as well as public investments. If the net present value of

²⁷ For example, if the supply elasticity of foreign capital is 1.0 instead of 1.5, the share of financing from foreign funds becomes smaller but the marginal cost of foreign funds is increased. As a consequence, the economic opportunity cost of capital increases to 11.49 percent. On the other hand, if the supply elasticity of foreign capital is increased to 2.0, the economic cost of capital would be 10.74 percent. Perhaps the most important element in determining the economic cost of capital is the gross-of-tax return on domestic investment. If the average rate of return is 1.0 percentage point higher than 13.0% of the base case, then the economic opportunity cost of capital would become 11.77 percent.

either type of project is negative when discounted by the economic cost of capital, the country would be better off if the project were not implemented. Estimates of the value of this variable for a country should be derived from the empirical realities of the country in question. Of course, the results of such a discounting effort are only as good as the underlying data and projection made of the benefits and costs for the project.

This chapter began with the presentation of alternative approaches to choosing discount rates for investment projects and reviewed their strengths and weaknesses. An approach that captures the essential economic features uses a weighted average of the economic rate of return on private investment and the cost of newly stimulated domestic and foreign savings. Most practitioners have chosen to use a discount rate that follows this weighted average opportunity cost of funds concept. This chapter has described a practical framework for the estimation of the economic opportunity cost of capital in a small open economy. The model considers the economic cost of raising funds from the capital market. It takes into account not only the opportunity cost of funds diverted from private domestic investment and private consumption, but also the marginal cost of foreign borrowing. This methodology for illustrative purpose is applied to the case of South Africa.

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Appendix 8.1

Return to Domestic Investment in South Africa, 1985-2004 (millions of Rands)

Year	Expressed in Current Prices									Expressed at 2000 Prices			Percentage Rate of Return
	GDP	Total Labor Income	Taxes on Products	Value Added Tax	Subsidies	GVA in Agriculture	Resource Rents	Depre- ciation	Return to Capital	GDP Deflator Index	Real Return to Capital	Capital Stock (Mid- Year)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1985	127,598	69,115	11,791	-	1,536	6,091	6,323	21,003	22,283	18.00	123,801	1,358,877	9.11
1986	149,395	80,969	13,946	-	1,814	6,831	8,994	26,348	22,725	21.07	107,850	1,377,945	7.83
1987	174,647	95,102	16,141	-	2,146	8,994	11,605	29,823	25,713	24.13	106,583	1,383,741	7.70
1988	209,613	111,556	20,936	-	2,241	11,149	12,269	34,521	35,504	27.79	127,766	1,391,734	9.18
1989	251,676	134,204	26,505	-	2,375	12,332	12,933	40,978	44,023	32.58	135,107	1,407,786	9.60
1990	289,816	158,557	29,153	-	2,488	12,184	13,596	45,990	50,249	37.64	133,494	1,425,970	9.36
1991	331,980	182,514	31,096	18,792	2,523	13,825	12,411	50,251	56,232	43.56	129,088	1,440,425	8.96
1992	372,227	209,129	33,190	17,506	4,519	13,056	11,227	54,227	66,457	49.91	133,156	1,448,246	9.19
1993	426,133	234,347	41,611	25,449	6,320	16,284	10,042	58,575	82,873	56.44	146,833	1,452,144	10.11
1994	482,120	260,776	48,373	29,288	6,400	20,252	11,005	64,500	98,830	61.86	159,775	1,458,980	10.95
1995	548,100	295,467	53,644	32,768	5,898	19,317	12,134	71,827	117,460	68.20	172,239	1,472,298	11.70
1996	617,954	332,191	58,119	35,903	5,635	23,720	13,115	78,817	137,366	73.71	186,353	1,492,361	12.49
1997	685,730	366,463	63,419	40,096	4,856	25,140	14,178	87,188	156,216	79.69	196,034	1,517,125	12.92
1998	742,424	401,632	74,473	43,677	6,923	25,434	15,271	96,615	158,848	85.83	185,067	1,544,460	11.98
1999	813,683	436,124	80,528	48,330	5,718	26,179	16,350	107,966	177,618	91.89	193,288	1,565,853	12.34
2000	922,148	478,812	87,816	48,377	3,886	27,451	17,792	119,237	226,708	100.00	226,708	1,580,321	14.35
2001	1,020,007	514,603	96,363	54,455	4,571	32,588	19,156	130,848	267,391	107.67	248,350	1,595,909	15.56
2002	1,164,945	564,357	109,820	61,057	4,664	44,179	21,126	149,329	329,119	118.74	277,180	1,612,489	17.19

2003	1,251,468	618,498	120,219	70,150	3,336	42,007	22,075	161,635	338,513	124.07	272,833	1,630,963	16.73
2004	1,374,476	676,231	146,738	80,682	2,671	41,323	23,377	172,394	372,402	131.39	283,428	1,656,231	17.11

Sources: For the period from 1985 to 2000, South African Reserve Bank, South Africa's National Income Accounts 1946-2004, (June 2005).

Notes:

Column (2) is obtained from the sum of wages and salaries paid by corporations and 35% of net operating surplus generated by unincorporated businesses.

Column (9) = (1) - (2) - (4) - 0.95*(1/3)*(6) - {(2)/[(1)-(3)+(5)]}*[(3)-(4)]-(7)-(8).

Column (12) is obtained from the total capital stock net of those of general government services.

Appendix 8.2

The Cost of Newly Stimulated Domestic Savings, 1985-2004 (millions of Rands)

Year	Expressed in Current Prices												Expressed at 2000 Prices	Percentage
	GDP	Total Labor Income	Taxes on Products	GVA in Agriculture	Resource Rents	Depreciation	Income and Wealth Taxes paid by Corporations	Income and Wealth Taxes paid by Households	Wages and Salaries Received by Households	Property Income Received by Households	Value Added in FIs, Real Estates	Return to Domestic Savings	Real Return to Domestic Savings	Rate of Return to Domestic savings
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1985	127,598	69,115	11,791	6,091	6,323	21,003	7,434	9,038	65,078	16,861	15,849	4,181	23,230	1.71
1986	149,395	80,969	13,946	6,831	8,994	26,348	8,486	10,513	75,444	18,772	17,312	2,096	9,949	0.72
1987	174,647	95,102	16,141	8,994	11,605	29,823	8,736	12,354	88,577	25,107	20,688	2,491	10,326	0.75
1988	209,613	111,556	20,936	11,149	12,269	34,521	10,194	14,468	103,565	34,228	25,069	6,746	24,276	1.74
1989	251,676	134,204	26,505	12,332	12,933	40,978	11,249	19,723	124,050	42,485	30,265	9,304	28,553	2.03
1990	289,816	158,557	29,153	12,184	13,596	45,990	15,284	23,831	146,240	49,541	36,039	8,338	22,151	1.55
1991	331,980	182,514	31,096	13,825	12,411	50,251	13,547	28,961	169,516	59,380	44,945	19,033	43,694	3.03
1992	372,227	209,129	33,190	13,056	11,227	54,227	10,963	35,050	193,250	73,942	53,265	26,341	52,778	3.64
1993	426,133	234,347	41,611	16,284	10,042	58,575	12,579	37,599	216,368	82,383	62,861	37,739	66,866	4.60
1994	482,120	260,776	48,373	20,252	11,005	64,500	14,565	45,280	240,416	94,052	76,491	46,132	74,580	5.11
1995	548,100	295,467	53,644	19,317	12,134	71,827	14,115	51,623	272,916	110,378	82,162	59,390	87,087	5.92
1996	617,954	332,191	58,119	23,720	13,115	78,817	21,408	59,496	306,225	121,807	94,122	66,332	89,987	6.03
1997	685,730	366,463	63,419	25,140	14,178	87,188	24,134	68,048	338,204	142,844	110,488	74,558	93,562	6.17
1998	742,424	401,632	74,473	25,434	15,271	96,615	29,935	75,422	370,589	155,866	122,227	63,557	74,048	4.79
1999	813,683	436,124	80,528	26,179	16,350	107,966	30,220	84,335	402,375	176,116	140,673	73,362	79,834	5.10
2000	922,148	478,812	87,816	27,451	17,792	119,237	33,248	87,848	440,299	206,496	156,252	109,440	109,440	6.93

2001	1,020,007	514,603	96,363	32,588	19,156	130,848	58,701	89,700	471,816	231,010	177,531	116,150	107,879	6.76
2002	1,164,945	564,357	109,820	44,179	21,126	149,329	68,807	95,801	515,053	271,925	204,590	153,266	129,079	8.00
2003	1,251,468	618,498	120,219	42,007	22,075	161,635	70,356	99,451	567,024	280,899	228,075	155,418	125,263	7.68
2004	1,374,476	676,231	146,738	41,323	23,377	172,394	75,343	108,628	618,215	305,088	247,514	169,534	129,029	7.79

Sources: For the period from 1985 to 2000, South African Reserve Bank, South Africa's National Income Accounts 1946-2004, (June 2005).
 Statistics South Africa, Final Supply and Use Tables 1998.

Notes: Column (12) = (1) - (2) - (3) - 0.95*(1/3)*(4) - (5) - (6) - (7) - (8)*{(10)/[(9) + (10)]} - (11)*0.5*0.5.
 Column (14) is obtained by dividing Column (13) by Column (12) of Appendix 8.1.

**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 9:**

***THE SHADOW PRICE OF FOREIGN EXCHANGE
AND NON-TRADABLE OUTLAYS***

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ABSTRACT

The economic cost of capital, as measured in Chapter 8, deals with the intertemporal comparisons. It links the annual flows of benefits and costs over a project's life to its initial capital investment. In the present chapter we deal with another facet of the act of raising project funds from the country's capital market. This facet concerns the distortions that are affected not intertemporally but at the same moment that the funds are raised. Investment and consumption expenditures by others in the market are displaced by the very act of raising the project's funds in the capital market. As a consequence, the government loses tariff revenue plus value added and other indirect taxes. These losses must be counted in the economic evaluation of any project, in addition to those linked to the spending of project funds on tradable or non-tradable goods and services, and in addition to the intertemporal distortions captured by the economic opportunity cost of capital. The existence of these indirect taxes on domestic and trade transactions, the economic value of foreign exchange differs from the market exchange rate and there will be a tax externality associated with expenditures on nontradables. This chapter has provided an analytical framework and a practical approach to the measurement of the economic cost of foreign exchange and the shadow price of non-tradable outlays.

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CHAPTER 9

The Shadow Price of Foreign Exchange and Non-Tradable Outlays

9.1 Introduction

The economic cost of capital, as measured in Chapter 8, deals with the intertemporal comparisons.¹ It links the annual flows of benefits and costs over a project's life to its initial capital investment. In the present chapter we deal with another facet of the act of raising project funds from the country's capital market. This facet concerns the distortions that are affected not intertemporally but at the same moment that the funds are raised. Investment and consumption expenditures by others in the market are displaced by the very act of raising the project's funds in the capital market. As a consequence, the government loses tariff revenue plus value added and other indirect taxes. These losses must be counted in the economic evaluation of any project, in addition to those linked to the spending of project funds on tradable or non-tradable goods and services, and in addition to the intertemporal distortions captured by the economic opportunity cost of capital

The starting point of this exercise is the calculation of the economic opportunity cost *or shadow price* of foreign exchange (EOCFX) and the shadow price of non-tradable outlays (SPNTO). Before starting, we want to make clear that at that point we are

¹ The issue of how project funds are raised has been source of constant discussion and debate. Our position -- which we believe to reflect a pretty close consensus among experienced practitioners -- is that one is very well advised to choose a standard type of sourcing for project funds, and that capital market sourcing is clearly the best candidate to serve as this standard. The next alternative would be sourcing from tax revenues -- but here there are a thousand alternative ways to get extra tax money, each involving a different weighted average of distortions. Capital market sourcing, by contrast, works on the basis of additional pressure in the capital market. We expect that an added demand for funds will have much the same effects regardless of whether the government is raising money to build dam, or a private firm is borrowing to renew its stock of trucks, or a group of consumers is borrowing to finance a joint vacation trip. The capital market does not "see" the purpose for which the funds will be used, it simply "feels" the added pressure. It is thus the forces of the market that ultimately determine what expenditures will be displaced. We thus proceed on the assumption of a standard pattern of distortions that are involved in the actual act of displacing consumption and investment (dealt with in the present chapter) plus a standard pattern of intertemporal distortions, impacting the economic opportunity cost of capital -- the rate of return -- dealt with in the preceding chapter.

accounting for the distortions involved in sourcing the money for our expenditures, and in causing equilibrium to be maintained in the market for foreign exchange, but we are explicitly not counting the distortions that are entailed (or engendered) as we spend that money, either on tradables, (for which the economic cost of foreign exchange captures the sourcing distortions), or on non-tradables, (for which the sourcing distortions are captured by the shadow price of non-tradable outlays). The procedure leading to EOCFX captures those distortion costs that are triggered each time money is sourced in the capital market and spent on tradables. Similarly, the calculation of SPNTO captures the distortion costs that are engendered each time money is sourced in the capital market and spent on nontradables. But once we are at that stage, the repetitive aspect vanishes. One project might buy an import good with an 80% tariff plus a 20% value added tax; another might import everything free of tariff and VAT; yet another might buy locally a taxed export product, leading to a loss of tax revenue by the government. It is similar with non-tradable goods; we may spend our money on items that are heavily taxed, lightly taxed, heavily subsidized, lightly subsidized or not subsidized or taxed at all. In all such cases, the analysis of each project must cover the specific distortions involved in the spending of project money, but this must be done separately, as part of the study of each project's costs and benefits -- it cannot be incorporated in a standardized measure like EOCFX or SPNTO.

Our cost-benefit analytical framework is developed to convert the financial receipts and expenditures of a project into values that reflect their economic worth. The financial analysis uses the market exchange rate to convert the foreign currency values of traded goods into units of domestic currency. The market exchange rate, however, usually does not reflect the economic value to the country of foreign exchange. In any such case, the conversion from foreign to domestic currency units should be done using EOCFX – the economic opportunity cost of foreign exchange, also known as its shadow price. The shadow price of foreign exchange is also needed for the valuation of the tradable inputs that are used directly or indirectly in the production of the non-tradable goods and services.

The most common source of a difference between the economic value and the market rate for foreign exchange stems from tariffs and non-tariff barriers. In a similar vein, we must incorporate export taxes and subsidies. These trade and other indirect tax distortions give rise to economic externalities every time that foreign currency is either extracted from or injected into the foreign exchange market.

To demonstrate how the economic value of foreign exchange may differ from its market value, we begin by considering a case in which it is the market exchange rate that moves to bring about an equilibrium of demand and supply. We also assume that the country cannot significantly influence the world prices of its exports or its imports. Under these conditions, we can measure the quantities of different traded goods in units of “dollar’s worth”, simply by counting copper in units of half a pound when its world price is \$2.00 per pound, wheat in units of one quarter bushel when its world price is \$4.00 per bushel etc. In this way the demand and supply curves for importables and exportables can be aggregates spanning many different commodities.

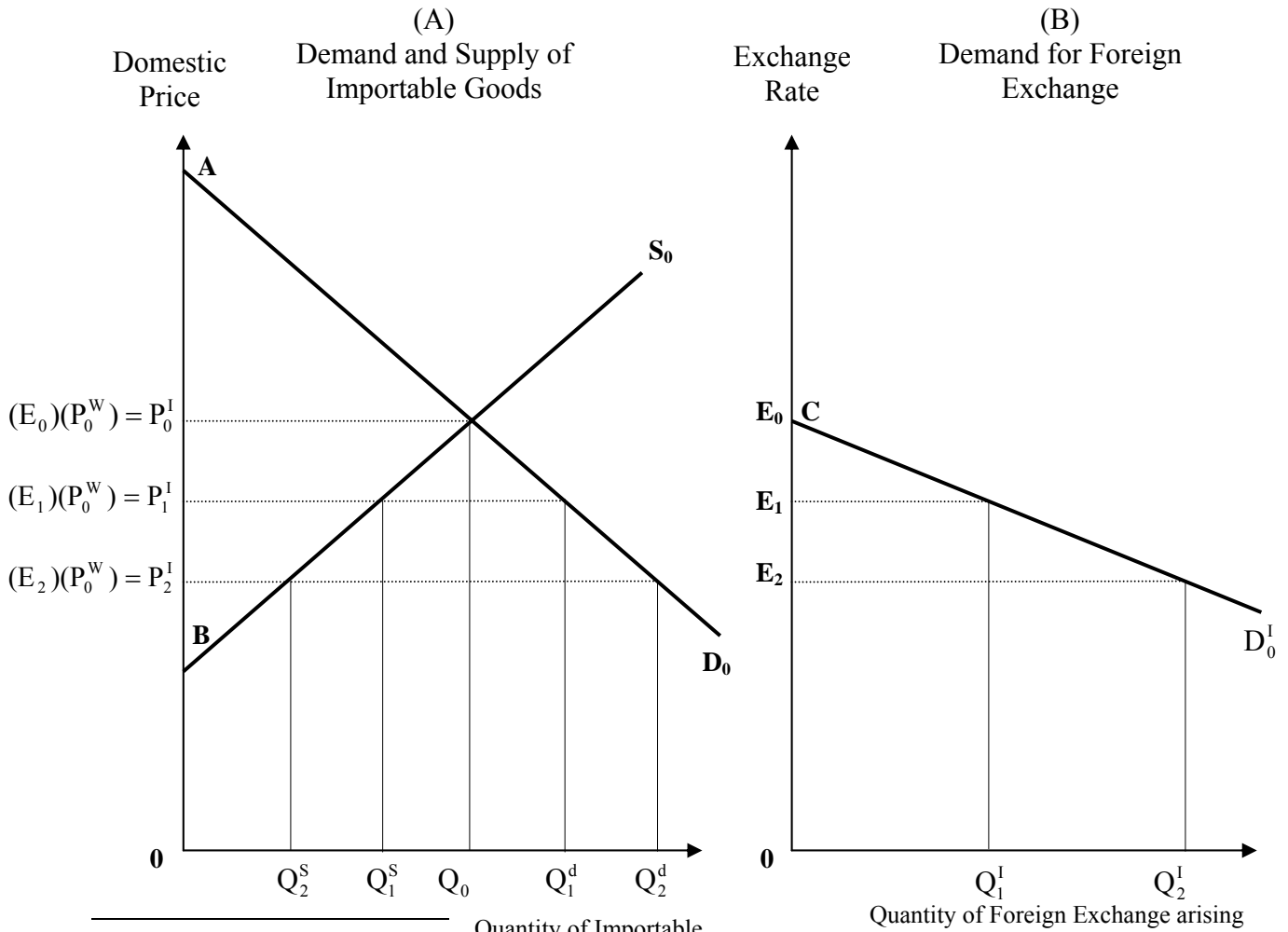
9.2 Determination of the Market Exchange Rate

Defining the exchange rate as the number of units of domestic currency per unit of foreign currency, the domestic prices of tradable goods will be linked positively to the market exchange rate. As the demand for foreign exchange is linked to the demand for imports, the quantity of foreign exchange demanded will fall as the market exchange rate rises and vice versa. This is illustrated in Figure 9.1 (A and B). In panel A the demand for importable goods (AD_0) is juxtaposed to the domestic supply of importables (BS_0). The definition and implication of importable (and exportable) goods will be elaborated in the next chapter.

For any given set of world prices for importable goods [assumed fixed at (P^w_0)], the domestic price will fall from (P^l_0 to P^l_2) as the market exchange rate falls from E_0 to E_2 . At each level of the exchange rate, the demand for foreign exchange is equal to the

difference between the demand for importable goods and the domestic supply of these goods.² When the exchange rate is at E_0 there will be no net demand for foreign exchange, because domestic production will be equal to the demand for these goods. As the exchange rate falls, the demand for importables will increase from Q_0 to Q_2^d while their domestic supply will fall from Q_0 to Q_2^s . Hence, imports will flow into the country to fill this gap. When the quantity of imports is measured in units of foreign exchange, the demand for foreign exchange will increase with the fall in the exchange rate as shown by the curve CD_0^1 in Figure 9.1B.

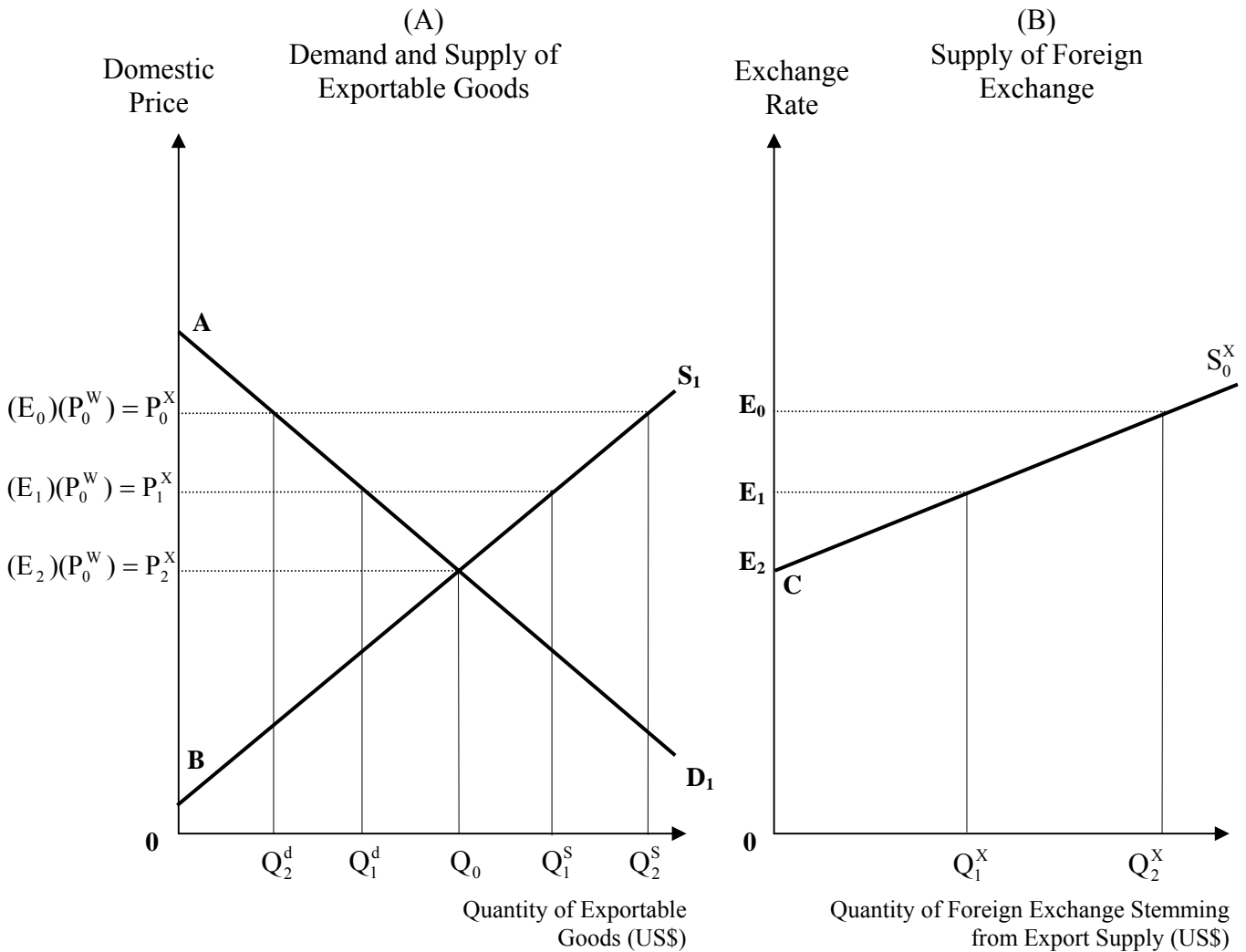
Figure 9.1: Importable Goods and the Demand for Foreign Exchange



² Since the demand for imports is an excess demand function, the elasticity of demand for foreign exchange will be greater than the elasticity of demand for importable goods even when the domestic supply of these items is completely inelastic.

In a similar fashion, the supply of foreign exchange is derived from the domestic supply and demand for exportable goods. Because the world prices of these goods are fixed, their domestic prices will be tied to the country's exchange rate. An increase in the exchange rate will lead to an increase in the domestic price of each item, which will in turn cause the supply of exportable goods to increase. The relationship between the demand and supply of exportable goods, and the supply of foreign exchange, is illustrated in Figure 9.2.

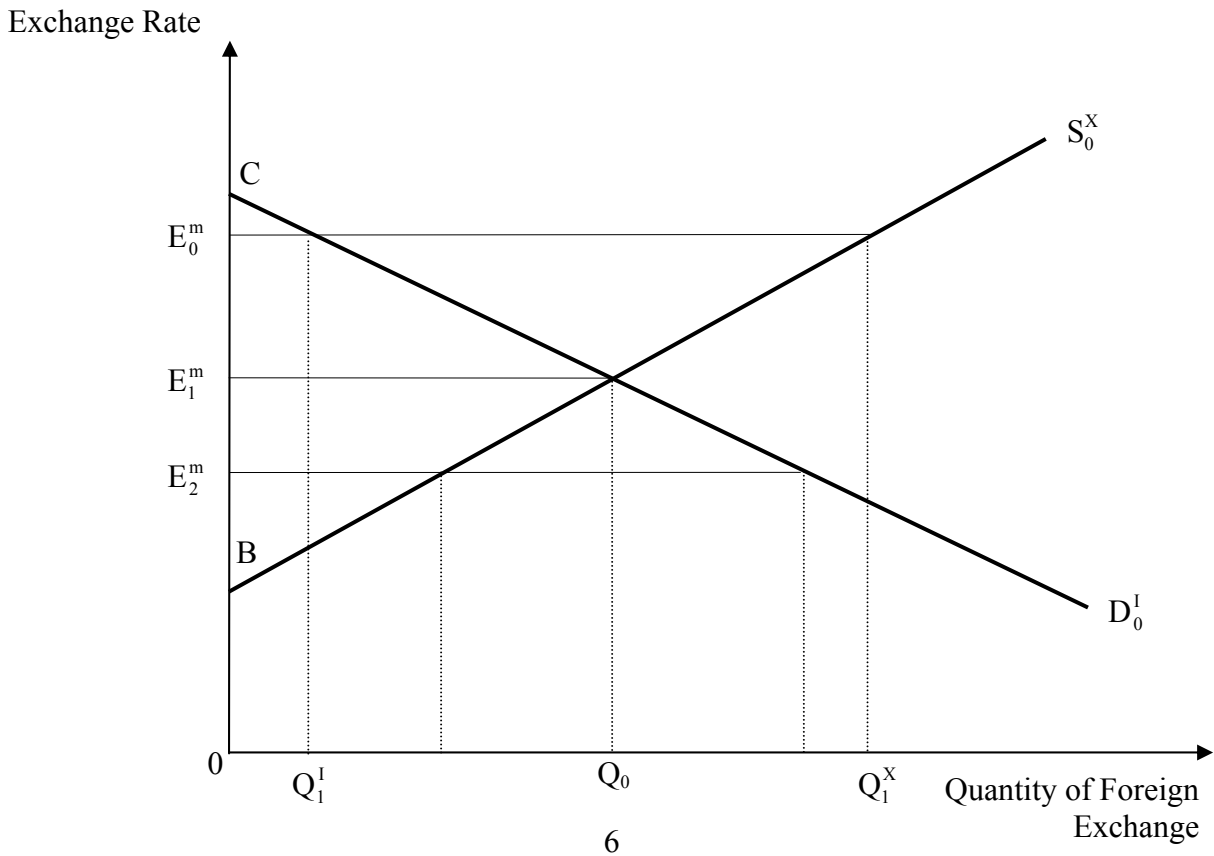
Figure 9.2: Exportable Goods and the Supply of Foreign Exchange



When the exchange rate is above E_2 , the supply of exportable goods (denoted by the curve BS_1) will be greater than the domestic demand for these goods (curve AD_1). Hence, exports will amount to $Q^s_1 - Q^d_1$ when the exchange rate is E_1 . These sales of exports abroad can also be expressed as the country's export supply curve, which is a function of the market exchange rate as shown in Figure 9.2B.

Determination of the equilibrium exchange rate requires that the quantity of foreign exchange demanded be equal to the quantity supplied. Combining Figures 9.1B and 9.2B into Figure 9.3 we find an equilibrium market exchange rate of E^m_1 . At an exchange rate of E^m_0 , there will be an excess supply of foreign exchange equal to $Q^x_1 - Q^l_1$ while at exchange rate of E^m_2 there will be an excess demand of $Q^l_2 - Q^x_2$. These situations can represent equilibria so long as capital movements or other transfers are present to finance the difference. Otherwise, market forces will lead to equilibrium at E^m_1 .

Figure 9.3: Determination of the Market Exchange Rate



$$Q_2^x$$

$$Q_2^I$$

9.3 Derivation of the Economic Price of Foreign Exchange

For an economy that has no taxes, subsidies, or other distortions on the demand or supply of its tradable goods, the equilibrium market exchange rate (E^m_1) will be equal to the economic cost of supplying an additional unit of foreign exchange. E^m_1 will also reflect the economic benefits of a marginal increase in the consumption of whatever goods or services might be purchased with an extra unit of foreign exchange. With the introduction of tariffs or subsidies on one or more tradable goods, however, a divergence will arise between the market price of foreign exchange and its economic value expressed in units of the domestic currency of the country.

Traditionally the study of the economic price of foreign exchange has been carried out using a partial-equilibrium analysis. Such studies looked only at the demand for imports and the supply of exports, giving no consideration to any externalities that might occur as the funds to buy imports are acquired or the funds generated by exports are deployed.³ In this chapter we first present the traditional, partial-equilibrium derivation of the economic cost of foreign exchange. Then the analysis is extended using a framework that takes into account how funds for buying imports are sourced, and /or how funds generated by exports are disposed of.⁴

9.3.1 A Partial Equilibrium Analysis

Nearly all countries levy tariffs on at least some imports, and one sometimes also finds

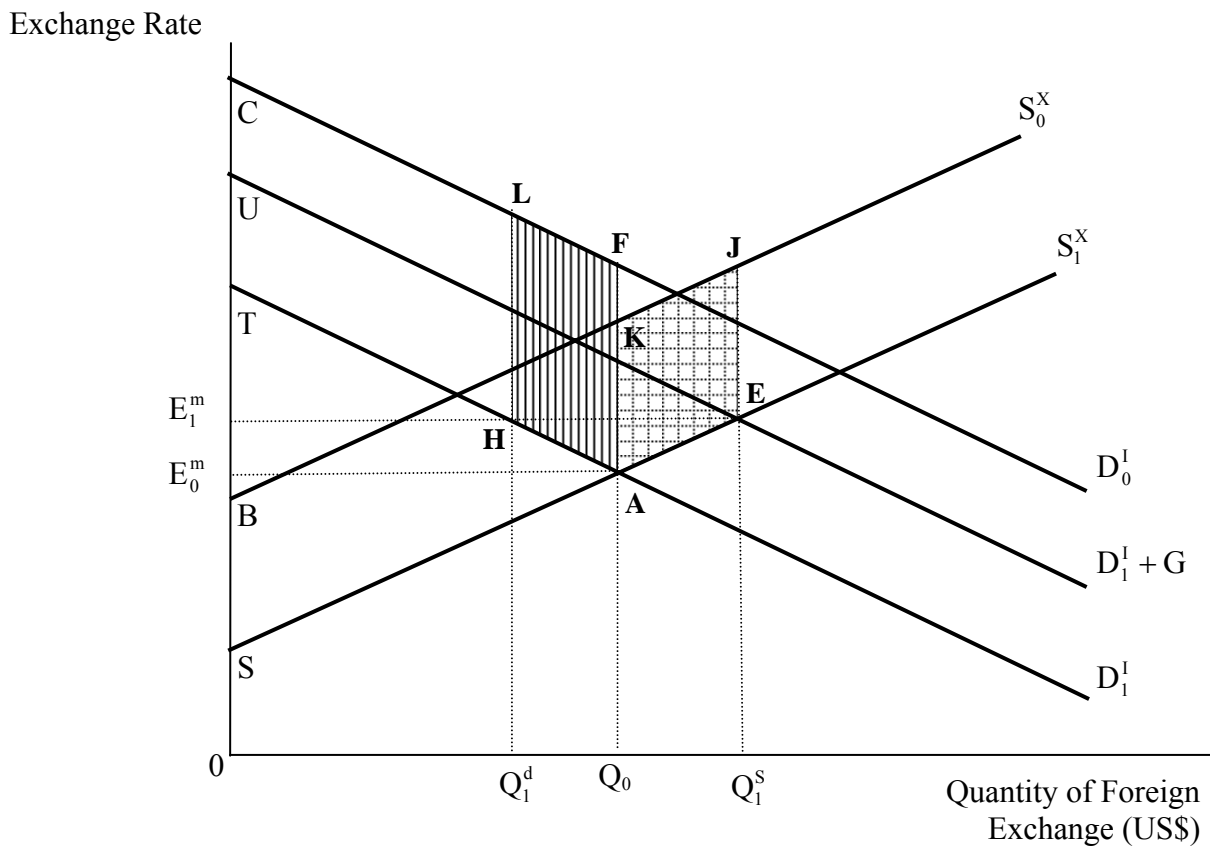
³ Harberger, A.C., "Survey of Literature on Cost-Benefit Analyses for Industrial Project Evaluation", United Nations Inter-Regional Symposium in Industrial Projects Evaluation, Prague, (1965); Bacha, E. and Taylor, L., "Foreign Exchange Shadow Prices: a Critical Review of Current Theories", *Quarterly Journal of Economics*, (1971); UNIDO, *Guideline for Project Appraisal*, New York: United Nations Publications, (1972); Fane, G., "The Social Opportunity Cost of Foreign Exchange: A Partial Defence of Harberger et al.", *Economic Record*, (December 1991).

⁴ Blitzer, C., Dasgupta, P. and Stiglitz, J., "Project Appraisal and Foreign Exchange Constraints", *Economic Journal*, (1981); Jenkins, G.P. and Kuo, C.Y., "On Measuring the Social opportunity Cost of Foreign Exchange", *Canadian Journal of Economics*, (1985); and Harberger, A.C. and Jenkins, G.P., "Introduction" edited by Harberger, A.C. and Jenkins, G.P., *Cost-Benefit Analysis*, Cheltenham: Edward Elgar Publishing Limited, (2002); Harberger, A.C., Jenkins, G.P., Kuo, C.Y. and Mphahlele, M.B., "The Economic Cost of

subsidies or taxes on exports. Here, we will first examine the relationship between the market exchange rate and its economic value for the case where there is a uniform tariff on imports and a uniform subsidy for exports.

The tariff will bring about a divergence between the domestic valuation of imports (willingness to pay) given by the demand curve CD^I_0 in Figure 9.4 and the demand for foreign exchange, shown by the curve TD^I_1 . Consumers' evaluation of these imports does not change when the tariff is imposed. Nevertheless, the amount of foreign exchange they are willing to pay the foreign supplier will fall because they have to pay the tariff to their own government in addition to the cif cost of the item to the importer. Thus, tariffs cause the economic value of foreign exchange to be greater than the market exchange rate.

Figure 9.4: Determination of the Economic Cost of Foreign Exchange with Tariffs and Subsidies



Foreign Exchange for South Africa”, *The South African Journal of Economics*, Vol: 71:2, (June 2003).

A subsidy on the sales of exports will lower the financial cost of producing an item, as seen from the point of view of the domestic supplier. However, the economic resource cost of production is still measured by the before subsidy supply curve BS^x_0 while the price at which producers are willing to export their goods is given by the curve SS^x_1 which includes the effect of the subsidy. Hence, subsidies will increase the supply of foreign exchange and cause the market exchange rate to be less than the economic cost of foreign exchange.

In such circumstances, the market exchange rate (E^m_0) will be determined by the interaction of the demand for foreign exchange (given by the net of tariff demand for imports TD^I_1) and the subsidized supply of foreign exchange SS^x_1 (arising from the supply of exports). The intersection of these two curves at point A in Figure 9.4 will determine the initial market exchange rate (E^m_0). At this exchange rate, the amount of foreign exchange bought or sold in the market is Q_0 units. The value consumers place on the goods, which can be purchased with a unit of foreign exchange, includes the tariffs they pay. This value is shown as the distance Q_0F . At the same time, the resources required to produce an additional unit of foreign exchange is reflected by the height of the supply curve that would have existed if there were no subsidy BS^x_0 , or the distance Q_0K . The existence of the subsidy means that producers will be induced to use a greater value of resources to produce an additional unit of exports than E^m_0 , which is the market value of the foreign exchange that the country receives from its sale.

Now let us consider what economic costs are incurred when a project requires G units of additional foreign exchange. We here neglect to inquire how the funds were raised that are used to purchase this foreign exchange (the traditional partial-equilibrium assumption). On this assumption all the foreign exchange bought by the project is generated through a rise in its domestic price. This is shown in Figure 9.4 by the shift in the demand curve for foreign exchange, from D^I_1 to $D^I_1 + G$. However, the demand curve D^I_1 still measures what people, other than the project, are willing to pay net of the tariff for each successive unit of foreign exchange. The project's action will cause the exchange rate to be bid up from E^m_0 to E^m_1 . This creates an incentive for exports to

expand and for consumers to decrease their demand for imports.

Producers of exportable items will supply additional foreign exchange of $Q_1^s - Q_0$ as the market exchange rate increases from E_0 to E_1 . The producers receive additional subsidy payments of $AKJE$ that will be spent on factors of production and intermediate inputs. The total value of resources required to produce this incremental output is given by the area $Q_0KJQ_1^s$. At the same time, consumers reduce their demand for imports (foreign exchange) by $Q_0 - Q_1^d$. As they reduce their purchases of imports they will also reduce their expenditures on import duties shown by $HLFA$. These import duties reflect part of what consumers are willing to pay for the imports they are giving up. Hence, the total economic value of the reduction in consumption is $Q_1^dLFQ_0$.

Combining the resource cost of the additional supply of exports with the reduction in consumer benefits from the cutback in consumption, we find that the total economic cost of the foreign exchange used by the project is equal to the sum of the two areas $Q_0KJQ_1^s$ and $Q_1^dLFQ_0$. Algebraically, the value of these two areas can be expressed as:

$$\text{Economic Cost of Foreign Exchange} = E^m Z (Q_1^s - Q_0) + E^m T (Q_0 - Q_1^d) \quad (9.1)$$

where E^m is the market exchange rate, Z is the subsidy per unit of exports and T is the tariff per unit of imports.

Expressing equation (9.1) in elasticity form, the economic cost of foreign exchange on a per unit basis (E^c) can be calculated as follows:

$$E^c = \frac{e^x E^m Q^x (1+k) - \eta^I(Q^I) E^m (1+t)}{e^x Q - \eta^I(Q^I)}$$

$$= E^m \cdot \left[1 + \frac{e^x k - \eta^I(Q^I / Q^x) t}{e^x - \eta^I(Q^I / Q^x)} \right] \quad (9.2)$$

where e^x is the supply elasticity of exports, η^I is the demand elasticity for imports, Q^I is the quantity of foreign exchange required to pay for imports, and Q^x is the quantity of foreign exchange earned from exports. Here k represents Z/E^m_0 , the amount of subsidy expressed as a fraction of the initial equilibrating exchange rate. Likewise, t represents T/E^m_0 .

Equation (9.2) shows that the traditional measure of the economic cost of a unit of foreign exchange is equal to the market exchange rate plus (less) the net revenue loss (gain) experienced by the government in tax revenue from the adjustment of the demands and supplies of tradable goods that accommodate the increase in demand for foreign exchange by the project. This economic cost of foreign exchange is often expressed in project evaluation as a ratio to the market exchange rate, (E^c/E^m) . The percentage by which E^c exceeds E^m is typically referred to as the foreign exchange premium. To get the economic price of any given importable good its cif value (measured at the market exchange rate) is simply augmented by the foreign exchange premium), i.e., multiplied by E^c/E^m . For an exportable good it is the fob price (measured at the market exchange rate) that is augmented by the exchange premium to arrive at its economic value.

Suppose we are using an importable good that has a financial cost of \$150, inclusive of a 20 percent tariff that has been levied on its cif price. As the tariff payment is not a resource cost to the economy the value of this item net of tariff, \$125, is the cost that must be paid in foreign exchange. Assume that the value of E^c/E^m is 1.10. In this case, to arrive at the economic value of the item (\$137.50), its net of tax cost \$125 is adjusted by

1.1. The adjustment in this case lowers the economic cost to the project of this item below its financial cost, hence increasing the net benefits of the project.

This process of adjustment eliminates \$25 of financial cost, while at the same time imposing \$12.50 of additional cost to reflect the additional economic value the foreign exchange has over and above its financial cost.

The object of this type of adjustment is to see to it that a project's use or generation of foreign exchange is priced to reflect its economic opportunity cost. For tradable goods the total conversion factor for a good is made up of two parts: (i) an *adjustment* factor this is specific to the good which eliminates from the financial costs any taxes that are directly levied on the item and (ii) the premium reflecting the degree that the economic cost of foreign exchange exceeds its market value ($E^e/E^m - 1$).

9.3.2 The Economic Cost of Foreign Exchange and the Shadow Price of Non-Tradable Outlays Using Funds from the Capital Market

To this point the estimation of the economic price of foreign exchange has *explicitly* not taken into account how the funds *are sourced* by the project to purchase the foreign exchange. The issue was raised and examined by Blitzer, Dasgupta and Stiglitz when alternative fiscal instruments such as income or commodity taxes were used as ways to finance a project.⁵ Jenkins and Kuo also estimated the foreign exchange premium for Canada by developing a multi-sector general equilibrium model and assuming the *funds were* raised through a personal income tax.⁶ These assumptions are nevertheless not consistent with the economic opportunity cost of capital, where the capital market is postulated to be the source of funding for the project.

⁵ Blitzer, C., Dasgupta, P. and Stiglitz, J., "Project Evaluation and the Foreign Exchange Constraints", *Economic Journal*, (1981).

⁶ Jenkins, G.P. and Kuo, C.Y., "On Measuring the Social Opportunity Cost of Foreign Exchange", *Canadian Journal of Economics*, (May 1985).

The act of raising funds in the capital market will reduce the demand for goods and services in distorted as well as undistorted markets, in both the tradable and non-tradable sectors. Hence, externalities are generated by the act of raising funds in the capital market. We here explore how the traditional measure of the economic opportunity cost of foreign exchange has to be modified in order to take these additional externalities into account.

Once the focus is broadened to include externalities generated by the act of raising the funds involved (by whatever means) it becomes clear that one must treat the purchase of nontradable goods in a fashion similar to tradables, as there will typically be a difference between the financial cost and economic cost of outlays on nontradables. The percentage difference between these financial and economic costs will be referred to here as the premium on non-tradable outlays, PNT.

The estimation of the economic opportunity cost of foreign exchange and the shadow price of nontradable outlays is carried out here using a three-sector general equilibrium framework in which the funds used to finance the purchase of tradable and nontradable goods are obtained via the capital market.⁷ The three sectors are importable, exportable and non-tradable goods and services. Distortions such as tariffs, value-added taxes and subsidies are also present in the model. As before, the capital market is taken as the standard source of project funds, and the external effects involved in sourcing will be the same regardless whether these funds are spent on either tradables or nontradables.

When a project is financed by extractions from the capital market, there are three alternative sources for these funds. First, other investment activities may be abandoned or postponed. Second, private consumption may be displaced as domestic savings are stimulated. Third, increased foreign savings (capital inflows) may be generated in response to additional demand pressure in capital market. Different sets of the external effects will be involved, depending on the particular sources (e.g., domestic vs. foreign) from which the funds were drawn and the types of expenditures made (e.g., tradable vs. non-tradable).

⁷ Harberger, A.C. and Jenkins, G.P., "Introduction" edited by Harberger, A.C. and Jenkins, G.P., *Cost-Benefit Analysis*, Cheltenham: Edward Elgar Publishing Limited, (2002).

In order to cover all aspects of the problem, four source-use combinations are here considered. The alternative sources are the domestic and foreign capital markets. The alternative uses represent project spending on tradables and non-tradables. We begin by considering the case of sourcing the funds from in the local capital market.

Domestically Sourced Funds Used to Purchase Inputs

When funds are extracted from the domestic capital market to finance the purchase of project inputs, there will be a displacement of investment or private consumption expenditures. These investment and consumption expenditures would otherwise have been made on importable goods, exportable goods and non-tradable goods. The ultimate quantitative impacts on the demand in the market for these three broad classes of goods will also depend on whether the project uses the funds to purchase tradable or non-tradable goods.

Funds Used only to Purchase Tradable Goods

When funds from the capital market are used to purchase importable goods, the natural result would be a net excess demand for tradables together with a net excess supply of non-tradables. To eliminate this disequilibrium, the exchange rate has to rise, causing the price of tradables relative to non-tradables to increase. As a consequence, the domestic demand for importables and exportables will decline and that for non-tradables will rise. At the same time, the producers of importables and exportables will find it profitable to produce more, and producers of non-tradables will produce less. The process will continue until a new equilibrium is reached in which there will be no excess demand or excess supply in the system.⁸ In other words, the exchange rate will adjust so as to ensure

⁸ This follows from properties of demand functions that the weighted sum of all the compensated price elasticities of demand (and supply) across all of the goods will always be equal to zero. That is, the real exchange rate will adjust until there is no excess demand (supply) for tradable and non-tradable goods in the system. This can be expressed as follows:

$$(\partial Q_{d,i}/\partial E) dE + (\partial Q_{d,e}/\partial E) dE + (\partial Q_{d,nt}/\partial E) dE = 0;$$

$$(\partial Q_{s,i}/\partial E) dE + (\partial Q_{s,e}/\partial E) dE + (\partial Q_{s,nt}/\partial E) dE = 0$$

Where E denotes foreign exchange rate; $Q_{d,i}$, $Q_{d,e}$, and $Q_{d,nt}$ stand for the demand for importable, exportable and non-tradable goods, respectively; $Q_{s,i}$, $Q_{s,e}$, and $Q_{s,nt}$ stand for the supply of importable, exportable and

that there is no excess supply of tradable goods market in the final equilibrium.

In the market for non-tradables, the reduction in demand caused by the initial capital extraction is somewhat offset by an increase in the quantity demanded (substitution effect) due to the decrease in their relative price. Similarly, the supply of non-tradable goods responds to the depressed market by contracting. Resources are released from the non-tradables sector will be used to help accommodate the increased demand in for tradables. Readers should recall that this entire analysis is carried out on the assumption of full economic equilibrium in the presence of existing distortions. Under this assumption, the total resources released from the non-tradable goods sector must equal the resources required for the additional production of importable and exportable goods.

In the case where funds are raised in the domestic capital market and spent on domestically produced exportable goods, the impact on the exchange rate turns out to be exactly the same as the case where the funds are spent on the purchase of importable goods.

Funds Used only to Purchase Non-tradables

In this case, the capital extraction plus the spending of all the funds on non-tradable items results in an excess demand for non-tradables. At the same time there is a reduction of spending on tradables due the extraction of funds via the capital market. To reach a new equilibrium, the relative price of non-tradables will have to increase, inducing resources to move from the tradables to the nontradables sector. This adjustment process is the reverse to that described in the case of funds spent on tradable goods.

Foreign Funds Used to Purchase Inputs for Project

When foreign funds are used to finance the project's inputs, the results are quite different

non-tradable goods, respectively.

In addition, the extraction of funds via the capital market results in a reduction in demand in both the tradable and non-tradable goods sectors. The reduction in demand for non-tradable goods will discourage their production until their supply equals their demand. This ensures that the following equation in the non-tradable goods sector is satisfied:

$$(\partial Q_{d,nt}/\partial B) dB + (\partial Q_{d,nt}/\partial E) dE - (\partial Q_{s,nt}/\partial E) dE = 0,$$

where dB stands for the amount of funds raised in the domestic capital market.

from the case treated above. Now there is no initial displacement of investment and consumption of tradable and non-tradable goods due to the capital extraction.

Moreover, when funds come from abroad to purchase tradable goods, no excess demand is generated for either foreign or domestic currency. However, when foreign sourced funds are spent on nontradables this will generate an increase in their relative price. At the new equilibrium, the supply of nontradables will have increased, and that of tradables will have decreased.

9.4 General Equilibrium Analysis: A Diagrammatic and Numerical Illustration

In this section concrete exercises are presented in order to illustrate how the general analysis can be put into practice. In doing so the two alternative sources of funds will be examined separately. We begin with the case of sourcing of project funds in the domestic capital market.

9.4.1 Sourcing of Funds in the Domestic Capital Market

Figure 9.5A shows the total supply and demand for tradable goods in an economy as a function of the real exchange rate (E). For the moment, we assume that there are no distortions in either sector.

(i) Impacts of Project Demand with No Distortions

If the project demand for tradable goods is 600, we do not assume that we move upward on the price axis to point E_u as shown in Figure 9.5A, where there is a gap of 600 between T_O^S and T_O^D , the quantities of tradables demanded and supplied.⁹ Instead we must take into account the fact that in raising 600 of funds in the capital market we have displaced the demand for tradables by some fraction (say 2/3) of this amount, and the

⁹ This is analogous to what was done in the partial-equilibrium scenario, where the sourcing of the funds was not considered.

demand for non-tradables by the rest (the other 1/3).

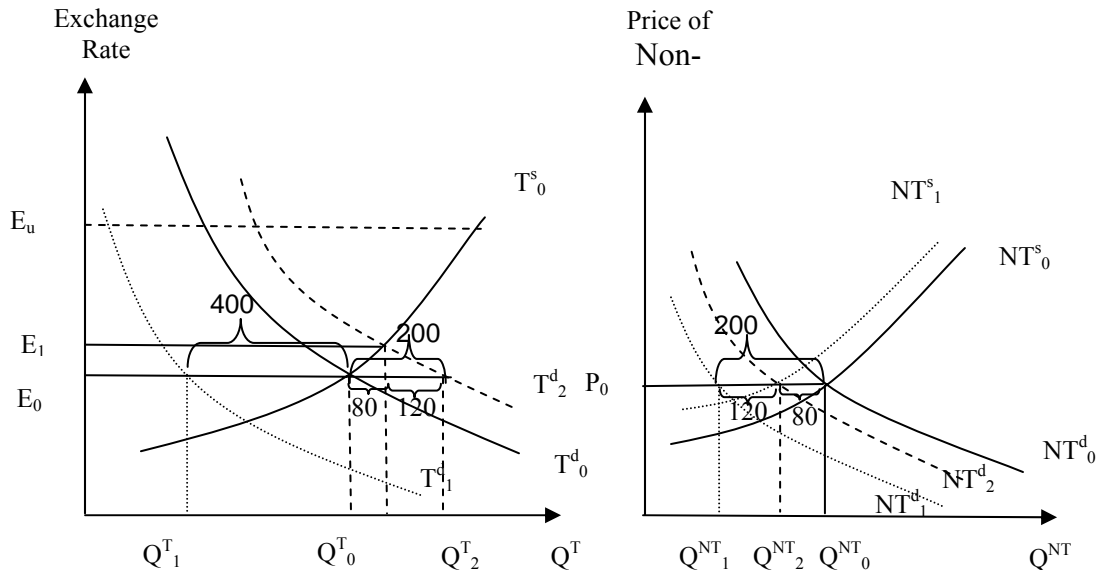
Our scenario, then, is that we shift the demand curve for tradables to the left by 400, and simultaneously insert a wedge of 600 representing the purchase of tradable goods to be used in the project, between that new demand T^D_1 and the supply curve of tradables T^S_0 . As all the 600 is spent on tradable goods, the demand for tradables shifts from T^D_1 to T^D_2 . At the exchange rate of E_0 there is now an excess demand for tradables of $Q^T_2 - Q^T_0$ or 200. Simultaneously, in the non-tradable goods market (Figure 9.5B), there is an excess supply, also of 200 ($(Q^{NT}_0 - Q^{NT}_1) = 200$). As a result, the real exchange rate rises from E_0 to E_1 . The 600 of tradables resources used by the project comes from three different sources -- a backward shift of tradables demand of 400, a movement backward along the "old" demand for tradables of 120 and a movement forward of 80 along the supply curve of tradables.¹⁰ In the non-tradable goods market, due to the decline in its prices relative to tradable goods, demand will increase by 120, as shown in Figure 9.5B. The net reduction in the demand for non-tradable goods becomes 80. In final equilibrium the supply of non-tradable goods will be reduced by 80 and the resources released from this sector will be absorbed in the expansion of the tradables sector.

¹⁰ This assumes that $|\eta^d_T| = 1.5 \epsilon^s_T$ where η^d_T denotes the demand elasticity for tradable goods while ϵ^s_T denotes the supply elasticity of tradable goods.

Figure 9.5**Impact of Domestically Sourced Funds Used to Purchase Tradable Goods**

A. Tradable Goods

B. Non-tradable Goods



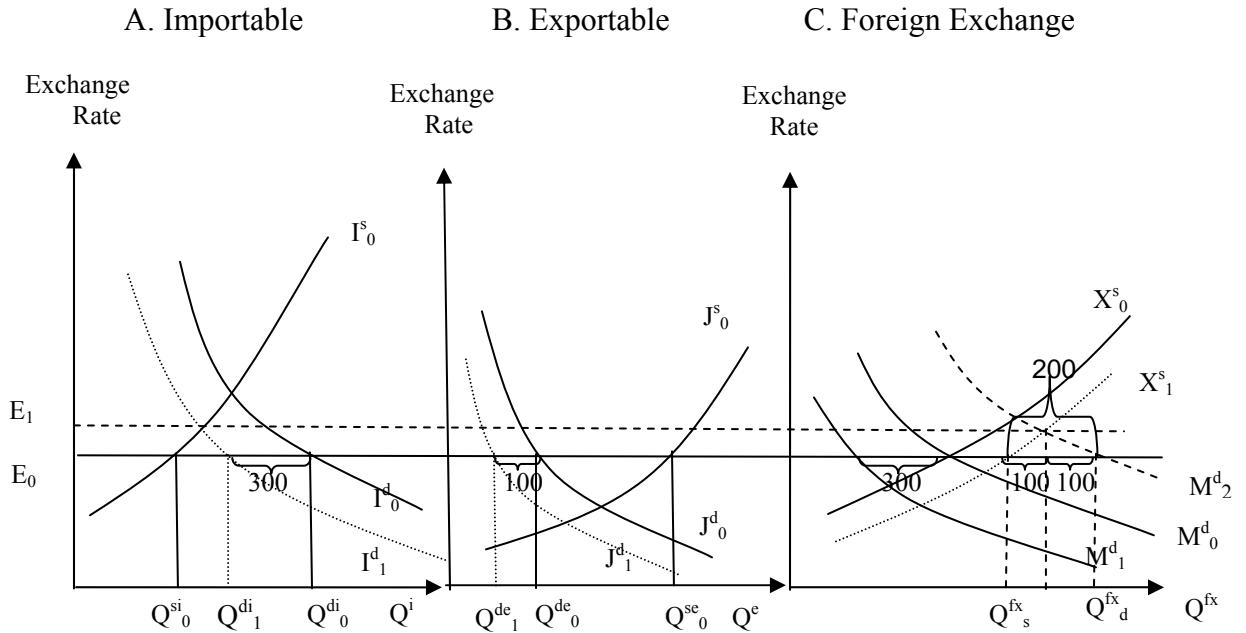
We will be able to use Figure 9.5 for a whole series of exercises, each involving a different set of distortions. In order to be able to do this, we have to interpret the demand and supply curves as being net of any distortions that are present in the system -- in particular, the demand for imports and the supply of exports are those which describe the market for foreign exchange. Thus, the import demand curve will be defined as being net of import tariff distortions and the export supply curve as being net of any export subsidy. Likewise, the demands for tradable and non-tradable goods will be defined to be net of the value added tax distortion. (When we make this assumption we are in no way constraining people's tastes or technologies. It should be clear, however, that we are not allowed, when we use this artifice, to trace the economy's reaction to the imposition of new tariffs or value added or other taxes or distortions). Readers can think of Figure 9.5 as representing the net position of different economies with different tax setups, but which happen to have the same set of "market" demand and supply curves for foreign currency, for tradables and for non-tradables.

Figure 9.6 tells the same story as Figure 9.5 but with important additional details. The connection between the two is the famous national accounting identity $(X^S - M^D) = (T^S - T^D)$, where X^S is the supply function of exports and M^D the demand function for imports. The shift of 400 in the demand for tradables has now to be broken down into a portion (here -300) striking the demand for importables and its complement (here -100) striking the demand for exportables, as shown in panels A and B. These components cause corresponding shifts in the import demand curve (shifting to the left by 300) and the export supply curve (shifting to the right by 100) as shown in panel C. With the purchase of 600 of importable goods there is an excess demand for foreign exchange of $Q_d^{fx} - Q_s^{fx}$ or 200. The exchange rate will rise to E_1 . This will cause the supply of export to increase by 100 and the demand for import to decrease by 100.¹¹

Note, however, that the movement along the supply curve of exports (+100) is different from the movement along the total supply curve of tradables (+80), and similarly that the movement along the demand function for imports (-100) is different from that along the demand for total tradables (-120). This simply reflects the fact that the demand for imports is an excess-demand function $I^d - I^s$, where I stands for importables, and that the export supply is an excess-supply function $J^s - J^d$, where J stands for exportables. The demand for tradables T^d is equal to $I^d + J^d$ and the supply of tradables T^s equals $I^s + J^s$.

¹¹ Assume that $|\eta_m^d| = \varepsilon_x^s$ where η_m^d denotes the demand elasticity for imports while ε_x^s denotes the supply elasticity of exports.

Figure 9.6: Foreign Exchange Markets



Thus, if we are asked, where did the 600 of foreign exchange come from, in order to meet our project's demand? We can actually respond with two equally correct answers. We can say that it came 520 from reduced demand for tradables and 80 from increased tradables supply. Or we can equally well respond that it came from a displacement in other imports of 400 and an increase in actual exports of 200. Both answers are correct, and if we do our calculations correctly, one will never contradict the other.

(ii) Introducing Import Tariffs

Suppose now that the only distortion present in this economy is a uniform import tariff (τ_m) of 12%. Given the shifts depicted in Figure 9.6, we have that the reduction in other imports (400) is twice as large as the increase in export supply. Our calculation of the economic opportunity cost of foreign exchange (E_e) would be:

$$E_e = 0.67 E_m(1.12) + 0.33 E_m = 1.08 E_m$$

The shifts depicted in Figure 9.6 are due to the way in which the money for the project

was obtained (or “sourced”), or is deemed to have been sourced. We here operate on the assumption that the standard source of funds at the margin is the capital market. When funds are withdrawn from the capital market, we assume here that they came either from displaced domestic investment or from newly stimulated domestic saving (displaced consumption). Later, we will bring in a third source -- capital flowing in from abroad -- to complete the picture.

In Figure 9.6 we show how this displacement of spending through the “sourcing” of the project’s funds is reflected in the demand for tradables taken as an aggregate (Figure 9.5A), and the demand for imports and the supply of exports considered separately (Figure 9.6C). Figure 9.5A is built on the assumption that the “sourcing” of 600 of project funds displaces tradables demand by 400 and non-tradables demand by 200. The reduction of 400 of demand for tradables is broken down into 300 affecting the demand for importables I^d and 100 affecting the demand for exportables J^d (see Panels A and B of Figure 9.6). These moves in turn are reflected in a leftward shift of the demand for imports ($M^d = I^d - I^s$) and in a rightward shift in the supply of exports ($X^s = J^s - J^d$). Because of these relations -- imports being one of excess demand, exports one of excess supply -- there is no reason why the slope of the X^s curve should be the same as that of the T^s curve, nor why there should be any similarity between the slope of T^d and that of M^d . Thus no contradiction is involved when the residual “gap” of 200 is filled 40% by a movement forward along T^s and 60% by a movement backward along T_0^d , while at the same time the filling of the same gap entails movements of equal amounts (100 each) forward along X_0^s and backward along M_0^d .

(iii) Introducing Value Added Taxation

For the most part, the literature on cost-benefit analysis has ignored value added taxation, and even indirect taxation in general, in its methodology for calculating the economic opportunity cost of foreign exchange and/or related concepts. Perhaps this is because value added taxes did not even exist before 1953, while the methodology of cost-benefit

analysis has roots going back far earlier. Also, many expositions of the value added tax treat it as a completely general tax, applying equally to all economic activities. This may have led cost-benefit analysts to assume that all sorts of resource shifts could take place as a consequence of a project without causing any net cost or benefit via the VAT, because the same rate of tax would be paid (on the marginal product of any resource) in its new location as in its old.

Our own real-world experience has led us to conclude, however, that the above assumption is grossly unrealistic. In the first place, value added taxes never strike anywhere near 100% of economic activities -- education, medical care, government services in general, the imputed rent on owner-occupied housing, plus all kinds of casual and semi-casual employment -- all typically fall outside the VAT net, even in countries which pride themselves on the wide scope of their value added taxes. In the second place, and partly for the reason just given, the effective average rate of value added taxation is typically much higher for the tradable goods sector than it is for non-tradables. Our work in Argentina and Uruguay, both of which at the time had “general” value added taxes of around 22%, suggested that actual collections are compatible with “effective” VAT rates of about 20% for tradables and of about 5% for non-tradables. In the exercise that follows we will use these VAT rates, together with an assumed general import tariff of 12%, to recalculate the economic opportunity cost of foreign exchange plus a new, related concept, the shadow price of non-tradable outlays.

The formal exercise to be performed is already illustrated in Figure 9.5. We assume we are raising 600 in the domestic capital market and spending it on tradable goods. In the process we displace 400 of other (non-project) imports, on which the tariff is 12%. The result is a distortion “cost” of 48 ($= .12 \times 400$). In addition we must take into account what is happening with respect to the value-added tax. In the tradables sector, non-project demand is displaced to the tune of 520 -- 400 from the leftward shift of demand due to the sourcing of project funds in the capital market, and 120 from the movement back

along T_0^d , which should be interpreted as a demand substitution away from tradables and toward non-tradables. The net result of all of this is a distortion cost of 104 ($= .2 \times 520$).

Finally, we turn to the non-tradables sector, whose movements are depicted in Figure 9.5B. The initial downward shift in the demand for non-tradables can be inferred to be 200, as 600 of funds was assumed to be raised in the capital market, of which 400 came from a downward shift of tradables demand. On the substitution side, we have the reflection of the downward movement of 120 in tradables demand (along the demand curve T_0^d). As this substitution is away from tradables it must be toward non-tradables. This leaves a net reduction of demand of 80 in the non-tradables market. The distortion cost here is 4 ($= .05 \times 80$), reflecting the effective VAT rate of 5%.

To close the circle we perform a simple consistency check. We have seen that, for the tradables, other demand is down by 520, and supply is up by 80. The difference here is represented by our project's own demand of 600, here assumed to be spent on tradables. So we have supply equal to demand, in the post-project situation, in the tradables market. Similarly, we have the supply of non-tradables down by 80 (reflecting the release of resources to the tradables sector), matched by a decline of 80 non-tradables demand, as shown in the previous paragraph.

To get the foreign exchange premium we simply add up the three types of distortion costs 156 ($= 48 + 104 + 4$) and express the result as a fraction of the 600 that our project is spending on tradable goods and services. Thus we have a premium of $156/600$, or 26%. Hence $E_e = 1.26 E_m$.

The related concept that we must now explore is the shadow price of non-tradables. To obtain this we perform an exercise quite similar to the one we have just completed, simply altering the assumption about how the money is spent. We can use Figure 9.7 to describe this case. Instead of assuming that project demand of 600 enters in the tradables

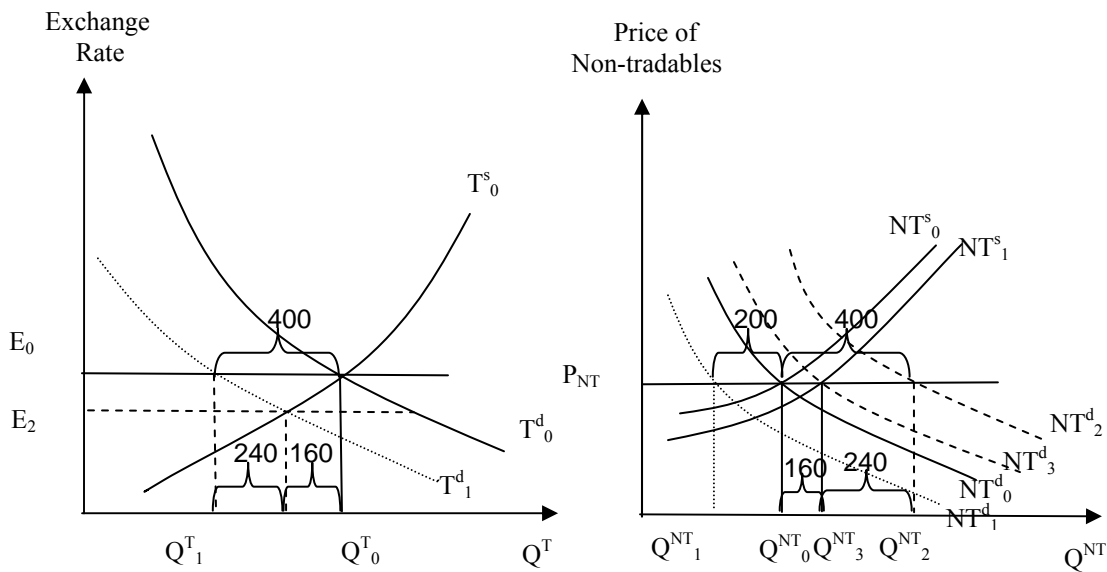
market to bid up the real exchange rate to E_1 , we instead have zero project demand for tradables, but the same “sourcing” shifts as before. The demand for non-tradable goods shifts from NT^d_1 to NT^d_2 . At the exchange rate E_0 , there is an excess supply of tradable goods of 400 ($Q^T_0 - Q^T_1$) and an excess demand for non-tradable goods of 400 ($Q^{NT}_2 - Q^{NT}_0$). This will cause the market exchange rate to fall to E_2 , resulting in an increase of the demand for tradable goods by 240 and a decrease in the demand for non-tradable goods by 240. At the same time, there will be a reduction of tradable goods supply by 160 – these resources being released in order to expand the production of non-tradables (to meet the incremental demanded due to their relative price decline).

Figure 9.7

Impact of Domestically Sourced Funds Used to Purchase Non-tradable Goods

A. Tradable goods

B. Non-tradable Goods



The move from the initial equilibrium at E_0 to the new one of E_2 , entails a net reduction of 100 in total imports (and also in non-project imports because the project is here demanding only non-tradables). On this the distortion cost is 12 ($= 100 \times .12$) from the 12% import tariff. In the tradables market the gap of 400 which exists at E_0 between T^s_0

and T_1^d , must be closed by moving along both curves.¹² Starting from the initial point at E_0 , the gap of 400 will be met by an increase of 240 along T_1^d , and by a decline of 160 along T_0^s . With a value added tax of 20% on tradables demand, we have a distortion cost of 32 ($= 160 \times 0.2$). (Tradables demand has shifted to the left by 400 and moved to the right along T_1^d , by 240.)

In the non-tradables market, we have a shift to the left of demand equal to 200 (from sourcing 600 in the capital market) plus the introduction of a new demand of 600. At the original real exchange rate E_0 this means a gap of 400 will be opened between supply and demand. The elimination of that gap entails the movement of the real exchange rate down to E_2 . In the process “old” non-tradables demand will decline by 240 (the counterpart of the movement from E_0 to E_2 along T_1^d) and non-tradables supply will increase by 160 (the counterpart of the movement along T_0^s between E_0 and E_2). So altogether we have a reduction of old non-tradables demand by 440. Applying the VAT rate of 5% to this decline, we have a distortion cost of 22 ($= .05 \times 440$).

Our total distortion cost in the case of project demand for non-tradables is thus 66 ($= 12 + 32 + 22$). Distributing this over a project demand for non-tradables of 600 we have a percentage distortion of 11%, and a shadow cost of project funds spent on non-tradables equal to 1.11 times the amount actually spent.

Consistency checks can now easily be made for this case. In the tradables market, supply has dropped (from the initial point E_0) by 160, moving along T_0^s , and demand has dropped by a like amount (a “sourcing” shift downward by 400, plus an increase along T_1^d of 240). In the non-tradables market we have 160 of extra resources, plus displaced demand of 440 (200 from the downward shift of non-tradables demand due to “sourcing”

¹² The example of the movements along T_1^d and T_0^s , between E_2 and E_0 , shows that this gap of 400 will be

of the funds to be spent, plus 240 of reduced non-tradables demand as people moved downward from E_0 to E_2 along T_1^d). Together, these are sufficient to free up the 600 of non-tradables output that our project is here assumed to be demanding.

(iv) *Introducing Value-Added-Tax Exclusions (Credits) for Investment Demand*

In the real world, most value added taxes are of the consumption type, and are administered by the credit method. In calculating its tax liability, a firm will apply the appropriate VAT rate to its sales, then reduce the resulting liability by the tax that was already paid on its purchases. In the consumption type of tax, this credit for tax already paid applies both to current inputs and to purchases of capital assets. In this way, investment outlays are removed from the base of the tax.

At first glance it would appear easy to correct our previous figure to accommodate this additional nuance, simply by scaling down the distortion costs we originally attributed to the VAT. On second thought, the matter is not quite so simple, for investment and consumption are likely to be very differently affected by the act of raising funds in the capital market on the one hand, and the process of demand substitution in response to real exchange rate adjustments, on the other. In particular, one should expect a large fraction (we here assume 75%) of the funds raised in the capital market to come at the expense of displaced investment, while a considerably smaller fraction would seem to be appropriate when a standard, price-induced substitution response is considered (we here use an investment fraction of one third). Thus, rather than a single adjustment to account for the crediting of tax paid on investment outlays, we have to make two adjustments -- one adjusting downward by 75% the distortion costs linked to the VAT in the response to the raising of project funds in the capital market, and the other, adjusting downward by one third the distortion costs (or benefits) associated with the readjustment of relative prices so as to reach a new equilibrium.

closed by a movement of 240 along T_1^d , and of 160 along T_1^s .

Tables 9.1 and 9.2 provide a very convenient format in which to make these adjustments. At the same time they can be used to show how the opportunity cost of foreign exchange and the shadow price of non-tradable outlays are modified as additional complications are introduced. The figures in the table correspond exactly to those underlying Figures 9.5-9.7 and embodied in our earlier calculations. There are three columns under the general rubric of distortion cost. In the first of these, only a 12% import tariff is considered. The point to be noted here is that even with this superclean and simple assumption, there is a need to allow for a shadow price of non-tradables outlays (see the first column under distortion costs in Table 9.1). In the second column a value added tax of 20% in tradables ($v_t = .2$) and of 5% on non-tradables ($v_h = .05$) is introduced. This yields precisely the numbers that emerged from the two exercises we have already conducted incorporating a value added tax.

Finally, in the third column under distortion costs we build in the exclusions (credits) for investment outlays. It is for this purpose that we have segmented the changes into two sets -- the first associated with the sourcing of project funds in the capital market, and the second linked with the substitution effects emanating from the real exchange rate adjustment corresponding to each case. Readers can verify that in the upper panels of Tables 9.1 and 9.2, the distortion costs linked to “tradables demand” and to “non-tradables demand” are reduced by 75% as one moves from the second to the third “distortion cost” column. Likewise, in the lower panels of these tables, the corresponding distortion costs are reduced just by one third as one moves from the second to the third distortion cost column.

This simple process of accounting for the crediting of investment outlays under the value added tax has a major effect on the calculation of the economic opportunity cost of foreign exchange and on the shadow price of non-tradable outlays. The former moves from $1.26 E_m$ to $1.1375 E_m$, while the SPNTO moves from 1.11 to 1.0175.¹³

¹³ The general formulae for calculating the economic values of the economic opportunity cost of foreign exchange and the shadow price of non-tradable outlays are presented in Appendix 9A. That appendix covers the cases of both domestic and foreign sourcing.

Table 9.1

**Calculation of the Economic Opportunity Cost of Foreign Exchange:
600 of Project Funds Sourced in Capital Market and Spent on Tradables**

				τ_m	v_t	v_h
			Applicable Distortion	τ_m Alone	v_t	v_h
					e_{is}	e_{ia}
<u>Change Due To Capital Market Sourcing</u>	Impact on Demand and Supply	(exclusion for investment $e_{is} = 0.75$)				
Tradables Demand	-400	$v_t = .20$	n.a.	-80	-20	
Import Demand	-300	$\tau_m = .12$	-36	-36	-36	
Export Supply	+100	-	n.a.	n.a.	n.a.	
Non-tradables Demand	-200	$v_h = .05$	n.a.	-10	-2.5	
<u>Change Due To Real Exchange Rate Adjustment</u>		(exclusion for investment $e_{ia} = 0.33$)				
Tradables Demand	-120	$v_t = .20$	n.a.	-24	-16	
Tradables Supply	+80	-	n.a.	n.a.	n.a.	
Import Demand	-100	$\tau_m = .12$	-12	-12	-12	
Export Supply	+100	-	n.a.	n.a.	n.a.	
Non-tradables Demand	+120	$v_h = .05$	n.a.	+6	+4	
Non-tradables Supply	-80	-	n.a.	n.a.	n.a.	
<u>Total Distortion Costs (-), Benefit (+)</u>			-48	-156	-82.5	
<u>Distortion Cost/ Project Expend. = Premium on Tradables Outlays</u>			.08	.26	.1375	
<u>Ratio of Economic to Market Exchange Rate</u>			1.08	1.26	1.1375	

Table 9.2
Calculation of the Shadow Price of Non-tradable Outlays:
600 of Project Funds Sourced in Capital Market and Spent on Non-tradables

			Applicable Distortion	τ_m Alone	τ_m v_t v_h	τ_m v_t v_h e_{is} e_{ia}
<u>Change due to Capital Market Sourcing</u>	Impact on Demand and Supply	(exclusion for investment $e_{is} = 0.75$)				
Tradables Demand	-400	$v_t = .2$	n.a.	-80	-20	
Import Demand	-300	$\tau_m = .12$	-36	-36	-36	
Export Supply	+100	-	n.a.	n.a.	n.a.	
Non-tradables Demand	-200	$v_h = .05$	n.a.	-10	-2.5	
<u>Change due to Real Exchange Rate Adjustment</u>		(exclusion for investment $e_{ia} = 0.33$)				
Tradables Demand	+240	$v_t = .20$	n.a.	+48	+32	
Tradables Supply	-160	-	n.a.	n.a.	n.a.	
Import Demand	+200	$\tau_m = .12$	+24	+24	+24	
Export Supply	-200	-	n.a.	n.a.	n.a.	
Non-tradables Demand	-240	$v_h = .05$	n.a.	-12	-8	
Non-tradables Supply	+160	-	n.a.	n.a.	n.a.	
<u>Total Distortion Costs (-), Benefit (+)</u>			-12	-66	-10.5	
<u>Distortion Cost/Project Expend. = Premium in Non-tradable Outlays</u>			.02	.11	.0175	
<u>Shadow Price of Non-tradable Outlays</u>			1.02	1.11	1.0175	

9.4.2 Sourcing of Funds in the Foreign Capital Market

The analysis of this section is built on the assumption that all of the project's funds are drawn from the external capital market. We do not consider this to be a realistic assumption except in rare cases (a point to be treated below) but it is an extremely useful expository device. Our plan is to calculate in this section the premia on tradables and non-tradables outlays on the assumption of sourcing in the external market, and then form a weighted average in which the premia applying to domestic sourcing and to foreign sourcing are combined, using weights designed to simulate the way natural market forces would respond to an increased demand for funds by the country in question.

Table 9.3 is presented in the same format as Tables 9.1 and 9.2. It differs only in that the project funds are assumed to be sourced in the external capital market instead of the domestic market. The first point to note is that we have no table dealing with the premia that apply when funds that are raised abroad are spent on tradables. The reason is that in such a case there should be no repercussion in the domestic market. If the funds are spent on imports, that simply means an extra truck or electric generator or ton of coal arrives at the country's ports. If the funds are spent on exportables that means that at the prevailing world prices of those exports (assumed to be determined in the world market and beyond the influence of the country in question), the country's exports will be reduced in the amount of the project's demand. Hence there is no variation of any distorted local market incidental to the spending of foreign-sourced funds on tradable goods.¹⁴

¹⁴ Readers should be aware that in developing the economic opportunity cost of foreign exchange and the shadow price of non-tradable outlays, we do not incorporate the distortions that apply to the products on which project funds are spent. These are taken into account as aspects of project's budgeted spending on specific items. Even with a uniform tariff, project imports often enter the country duty free (especially when imported by government agencies). More generally, we must know the specific imports of a project before we can determine what tariff rate applies. The case is similar with the value-added and other indirect taxes. We take all relevant distortions into account at some point in the analysis. The question is not whether we count them but where. The whole concept of economic opportunity costs and shadow prices presupposes that essentially the same pattern of distortions is involved each time a certain operation (e.g., spending project funds on tradables or non-tradables) takes place. The use of E_c and SPNTO represents a shorthand way of taking into account such repetitive patterns of distortions. Hence in calculating them we want to include all relevant parts of such a repetitive pattern. But we do not want to take into account idiosyncratic distortions -- i.e., those that depend in the particular pattern in which project funds are spent. These come into the cost-benefit calculus at the point where these specific outlays are treated.

The situation is quite different when money from abroad is allocated to the purchase of non-tradables. As shown in Figure 9.8, this would be reflected in an excess supply of foreign exchange, together with an excess demand of 600 in the non-tradables market. This situation is quite analogous to that at E_2 in Figure 9.7 which represents an excess demand for non-tradables of 400. So we expect the same kind of story as is told in Table 9.2, except that we do not have the distortion costs stemming from sourcing in the domestic capital market (and shown in the upper panel of Table 9.2). And, of course, the story of the bottom panel of Table 9.2 has to be augmented by 50% to reflect an excess non-tradables demand of 600 rather than 400. To meet this demand in the non-tradables market, 600 of foreign exchange must be converted to local currency. This entails stimulating imports by 300 (along the demand curve for imports) and displacing exports by a like amount (along the supply curve of exports). These movements are shown under import demand and export supply in panel C. The real exchange rate moves to a level E_3 as the same as shown in panel A, which entails a movement of 360 forward along the demand curve for tradables and one of 240 downward along the supply curve of tradables.

We thus have 240 less of tradables being produced, hence 240 more of non-tradables. And we have 360 more of tradables being demanded. This uses up 360 of the 600 of foreign exchange that came in to finance the project. The other 240 replaces the reduction in tradables supply, just mentioned.

Figure 9.8

Impact of Funds Borrowed from Abroad and Used to Purchase Non-tradable Goods

A. Tradable goods

B. Non-tradable Goods

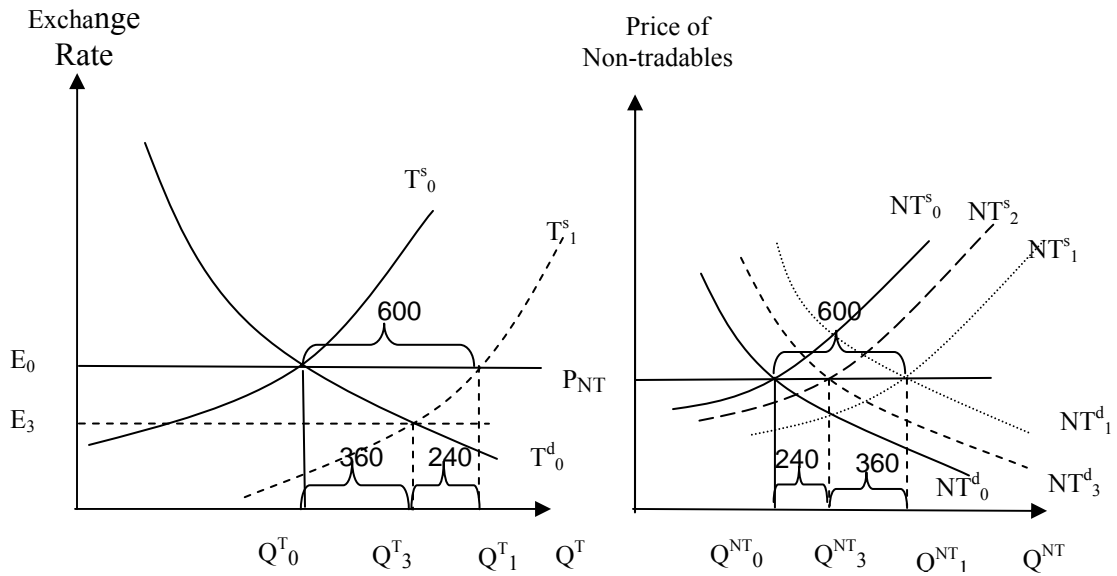
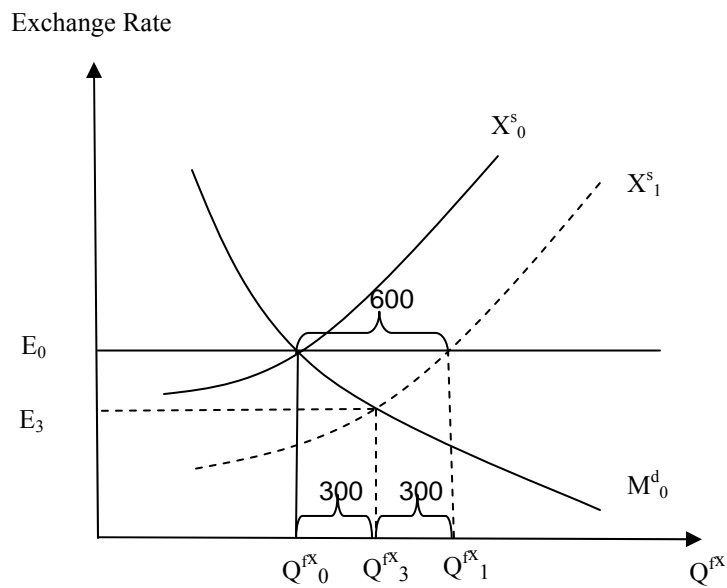


Figure 9.8

Impact of Funds Borrowed from Abroad and Used to Purchase Non-tradable Goods

C. Foreign Exchange Market



The 600 of project demand for non-tradables is met from the 240 of increase in their supply, plus the 360 induced reduction in their demand (the counterpart of the increase in demand for tradables induced by the fall in the real exchange rate from E_0 to E_3). The same gap of 600 which is closed by an increase of 300 in imports and a fall of 300 (panel C) in exports is reflected in an increase of 360 in total tradables demand and a fall of 240 in total tradables supply, as shown in panel A. These being substitution effects, they are reflected in moves of equal magnitude and opposite sign for the non-tradables (panel B).

Table 9.3 should be easy to interpret. It follows exactly the same principles as Tables 9.1 and 9.2. The only notable feature of Table 9.3 is that, rather than distortion costs, we obtain in each case an external benefit from the use of foreign-sourced funds in order to purchase non-tradables. In the example of Table 9.3, we have an external benefit of 6% of the expenditure on non-tradables when there is only a 12% tariff, a 15% benefit with that tariff plus a value added tax ($v_t = .20$; $v_h = .05$) with no credit in investment goods purchases, and a 12% percent benefit in the final case, when such a credit is given. All this comes from the facts that: a) there is no external effect linked with the actual sourcing of the (foreign) funds in this case; b) that there is an unequivocal benefit (tariff externality) from the increase in imports that this case entails; and c) that the demand substitution involves more spending on tradables with a higher VAT ($v_t = .20$) and less (substitution-induced) spending on non-tradables with a lower VAT ($v_h = .05$).

Table 9.3
Calculation of Shadow Price of Non-tradables:
600 of Project Funds Sourced abroad and Spent on Non-tradables

	Impact on Demand and Supply	Applicable Distortion (exclusion for investment $e_{is} = 0.75$)	τ_m Alone	τ_m v_t v_h	v_t v_h e_{is} e_{ia}
<u>Change Due To Capital Market Sourcing</u>		(exclusion for investment $e_{is} = 0.75$)	n.a.	n.a.	n.a.
<u>Change Due To Real Exchange Rate Adjustment</u>		(exclusion for investment $e_{ia} = 0.33$)			
Tradables Demand	+360	$v_t = .2$	n.a.	+72	+48
Tradables Supply	-240	-	n.a.	n.a.	n.a.
Import Demand	+300	$\tau_m = .12$	+36	+36	+36
Export Supply	+300	-	n.a.	n.a.	n.a.
Non-tradables Demand	-360	$v_h = .05$	n.a.	-18	-12
Non-tradables Supply	+240	-	n.a.	n.a.	n.a.
<u>Total Distortion Costs (-), Benefit (+)</u>			+36	+90	+72
<u>Distortion Cost/ Project Expend. = Premium on Non-tradables Outlays</u>			-0.06	-0.15	-0.12
<u>Shadow Price of Non-tradable Outlays</u>			0.94	0.85	0.88

9.4.3 Sourcing of Funds from both Domestic and Foreign Capital Markets

In Table 9.4 we combine Tables 9.1, 9.2 and 9.3, calculating weighted average premia for tradables and non-tradables outlays. We use weights $g_d = .7$ and $g_f = .3$, indicating a

70/30 split as between domestic and foreign sourcing of funds. These weights may appear arbitrary, but in principle one should think of them as market-determined. A simple supply and demand exercise, with many suppliers meeting a total demand, leads to the prediction that an increment of demand may in the first instance fall on one supplier or another, but market equilibrium requires that in the end, all suppliers will move upward along their supply curves from the old to the new equilibrium price. The distribution of the increased quantity among the different suppliers thus depends on the slopes of the supply curves from different sources.

We follow the same logic in thinking of the distribution of sourcing between the domestic and the foreign capital markets. We profoundly reject the idea that developing countries face an infinitely elastic supply curve of funds at the world interest rate (or at the world interest rate plus a specified country risk premium). The implications of such a setup are far too strong for us (and for most economists familiar with developing countries) to accept. For example: a) even government investments financed in the first instance by borrowing in the domestic capital market will in the end be effectively financed from abroad; this means no crowding out of domestic investment via the local capital market; b) any new increment to public or private saving will end up abroad; c) any new increment to public or private investment will end up being financed from abroad; d) the economic opportunity cost of public funds is simply the world interest rate (plus a country-risk premium, where applicable).

Rather than try to live with the above unrealistic implications of a flat supply curve of funds facing the country, we postulate an upward rising curve. This means that funds drawn from the capital market are effectively sourced from: a) displaced other investments, b) newly stimulated domestic savings (displaced consumption), and c) newly stimulated “foreign savings”, i.e., extra foreign funds obtained by moving forward along the supply curve of such funds, facing the country.

Table 9.4
Weighted Average Premia with “Standard” Capital Market Sourcing

Applicable Distortions	Project Funds Sourced From:		
	Domestic Capital Market	Foreign Capital Market	Both Markets $g_d=.7, g_f=.3$
$\tau_m = .12$			
Project Funds Spent on:			
Tradables	.08	0	.056
Non-tradables	.02	-.06	-.004
$\tau_m = .12, v_t = .20, v_h = .05$			
Project Funds Spent on:			
Tradables	.26	0	.182
Non-tradables	.11	-.15	.032
$\tau_m = .12, v_t = .20, v_h = .05, e_{jh} = .75, e_{ja} = .33$			
Project Funds Spent on:			
Tradables	.1375	0	.09625
Non-tradables	.0175	-.12	-.02375

Notes: g_d : fraction of project funds effectively sourced in the domestic capital market;
 $g_f (=1-g_d)$: fraction of project funds effectively sourced in the foreign capital market.

Items a) and b) were incorporated in the analysis of Tables 9.1 – 9.2. The effects of item c) are traced in Table 9.3. Table 9.4 joins the two types of sourcing on the assumptions indicated.¹⁵ It is interesting to note that within each panel of Table 9.4, the difference between the premia on tradables and non-tradables remains the same as one moves from one sourcing to another. This makes perfect sense. In the middle column we have the polar cases, of 600 being spent on tradables or on non-tradables, with no distortion costs associated with the sourcing of project funds. The benefits appearing there (as negative premia for non-tradables outlays) represent the net externality linked to closing an excess demand gap of 600 in the non-tradables market. This same gap is split, in the cases of

¹⁵ An added implication of an upward rising foreign supply curve of funds is that the marginal cost of funds lies above the average cost, i.e., above the interest rate actually paid. It is this marginal cost which is averaged in, along with the estimated marginal productivity of displaced investment and the marginal rate of time preference applicable to newly stimulated saving, in order to obtain the economic opportunity cost of capital -- i.e., the appropriate rate of discount for public-sector projects.

Tables 9.1 and 9.2 between an excess supply of 200 in the first case and an excess demand of 400 in the second.

9.5 Country Studies: Shadow Price of Foreign Exchange and Non-tradable Outlays for South Africa

South Africa is a small, open and developing country. This section provides the empirical estimation of the shadow price of foreign exchange and non-tradable outlays for South Africa using the general equilibrium framework developed in the previous section.¹⁶ The key parameters used in the estimation include:

- Project funds sourced in capital markets: domestic market (g_d) = 74%, foreign market (g_f) = 26%.
- Of funds sourced in the domestic market, 61.4% comes from displaced demand for tradables, 38.6% from the displacement of nontradables demand.
- In the capital extraction, the fraction of the displaced goods that come at the expense of displaced investment (e_{is}) is 84.4%. In the case of the substitution effect due to change in relative prices between tradables and non-tradables, the corresponding fraction that belongs to investment goods (e_{ia}) is 19.6%.
- Distortions:
 - Effective tariff rate (τ_m) = 3.60%;
 - Value added tax rates: tradables (v_t) = 11.36%, non-tradables (v_h) = 6.54%;
 - Excise duty rates: tradables = 5.63%, non-tradables = 0%;
 - Subsidy rate as a percentage of gross value added = 0.60%.

¹⁶ The empirical results in this section are obtained from Harberger, A.C., Jenkins, G.P., Kuo, C.Y. and Mphahlele, M. B., "The Economic Cost of Foreign exchange for South Africa", *South African Journal of*

The values of the externalities created by project funds spent on tradables and non-tradables depend on the weights at margin given to various sources of funds. They are summarized in Table 9.5. Using 74% as the fraction of project funds sourced in the domestic capital market and 26% as the fraction sourced in the foreign market, we estimate the economic opportunity cost of foreign exchange to be approximately 6 percent higher than the market exchange rate. The corresponding shadow price of non-tradable outlays is about 1 percent. This suggests that the additional cost of using, or the benefit from generating, foreign exchange in South Africa would be approximately 6 percent of the market value of tradable goods. At the same time, there is one percent premium on the expenditures or receipts of non-tradable goods. These figures represent the value of the generalized distortions that are created by differences between the economic and the market value of expenditures on tradable and non-tradable goods, respectively.

Table 9.5
Premia for Tradable and Non-tradable Outlays in South Africa
(percentage)

Funds drawn from	Funds Spent on Tradables	Funds Spent on Non-tradables
Domestic Capital Market	- 8.21	- 3.06
Foreign Capital Market	0	+5.15
Both Markets (a weighted average)	- 6.08	- 0.93

9.6 Conclusion

This chapter has provided an analytical framework and a practical approach to the measurement of the economic cost of foreign exchange. Because of the existence of indirect taxes on domestic and trade transactions, the economic value of foreign exchange differs from the market exchange rate.

Thus when moving from the financial to the economic flows of costs and benefits of a project deriving from the tradables sector, we must introduce adjustments to account for the difference between the economic opportunity cost of foreign exchange and the market exchange rate. At the same time we must adjust the cost and benefit flows related to nontradables so as to reflect the shadow price of nontradable outlays.

The analysis of this chapter began with a resume of the traditional partial-equilibrium framework, in which the demand and supply for the tradable goods or services are not affected by the way in which project funds are raised. It then moved to a general equilibrium analysis which additionally took into account the sourcing of the funds to finance the project's purchases. In the process, it became clear that adjusting for the sourcing of funds entails premia (or discounts) not only for the economic value of foreign exchange but also for nontradables outlays.

This general equilibrium framework was illustrated by examples in which import tariffs, value added taxes and investment credits were sequentially introduced. Additionally, two types of sourcing (domestic and foreign) of project funds were examined. These illustrations showed how the needed adjustments varied from case to case. Finally, this framework was applied to the estimation of the economic opportunity cost of foreign exchange for South Africa. The resulting estimate of the foreign exchange premium was approximately six percent of market value of tradable goods. The corresponding premium for non-tradable outlays was about one percent. These figures represent the value of the generalized distortions in South Africa that are created by differences between the market and the economic value of expenditures on tradable and non-tradable goods, respectively, when the funds used to make these expenditures are sourced from the capital market, with 26 % of the funds coming (directly or indirectly) from abroad.

Appendix 9A

A General Form for Estimating the Economic Value of Foreign Exchange and Non-tradable Outlays

General expressions for estimating the economic value of foreign exchange (E_e) and non-tradable outlays (SPNTO) have strong advantages over numerical exercises. Hence we here present them, together with numerical checks based on the exercises of Tables 9.1 and 9.2.

Definitions:

s_1 : share of project funds sourced by displacing the demand for importables,

s_2 : share of project funds sourced by displacing the demand for exportables,

s_3 : share of project funds sourced by displacing the demand for non-tradables,

f_1 : fraction of a gap between the demand for imports and the supply of exports that is closed by a movement along the demand function for imports as the real exchange rate adjusts to bring about equilibrium,

δ_1 : fraction of a gap between the demand and the supply of tradables that is closed by a movement along the demand function for tradables as the real exchange rate adjusts to bring about equilibrium,

c_1 : fraction of the change in value added stemming from a capital market intervention, that takes the form of consumption goods and services,

c_2 : fraction of the change in value added stemming from an equilibrating real exchange rate adjustment that takes the form of consumption goods and services.

Table 9A summarizes the general expressions for the premia on tradables and non-tradables outlays. This table follows the same sequence as Tables 9.1 and 9.2 -- i.e., first the case of a uniform tariff (τ_m) as the only distortion is treated; second, the value added taxes v_t and v_h on tradables and non-tradables are added to τ_m , but with no credit for

outlays on investment goods. Finally, the credit for such outlays is added, with the realistic assumption that investment goods will represent a higher fraction of the spending that is displaced by sourcing in the capital market than they will of spending that is displaced or added via price-induced substitution effects.

Table 9A
Expressions for Premia on Tradables and Non-tradables
(Project Funds Sourced 100% in Domestic Capital Market)

With Uniform Import Tariff (τ_m) Alone:

$$\begin{aligned} \text{Premium on Tradables} &= (s_1 + f_1 s_3) \tau_m \\ \text{Numerical Check:} & .08 = [0.5 + 0.5(.33)](0.12) \end{aligned}$$

$$\begin{aligned} \text{Premium on Non-tradables} &= [s_1 - f_1(s_1 + s_2)] \tau_m \\ \text{Numerical Check:} & .02 = [0.5 - 0.5(.67)](0.12) \end{aligned}$$

With Uniform Import Tariff (τ_m) Plus Value Added Taxes (v_t and v_h)
(No Credit for Investment Goods)

$$\begin{aligned} \text{Premium on Tradables} &= (s_1 + f_1 s_3) \tau_m + (s_1 + s_2) v_t + s_3 v_h + \delta_1 s_3 (v_t - v_h) \\ \text{Numerical Check:} & = .08 + (.67)(0.2) + .33(0.05) + 0.6(.33)(0.15) \\ & .26 = .08 + .1333 + .0167 + .03 \end{aligned}$$

$$\begin{aligned} \text{Premium on Non-tradables} &= [s_1 - f_1(s_1 + s_2)] \tau_m + (s_1 + s_2) v_t + s_3 v_h - \delta_1 (s_1 + s_2) (v_t - v_h) \\ \text{Numerical Check} & = .02 + .1333 + .0167 - (.6)(.67)(0.15) \\ & .11 = .02 + .133 + .0167 - .06 \end{aligned}$$

With Uniform Import Tariff (τ_m) Plus Value Added Taxes (v_t and v_h)
(With Credit for Investment Goods)

$$\begin{aligned} \text{Premium on Tradables} &= [(s_1 + f_1 s_3) \tau_m] + c_1 [(s_1 + s_2) v_t + s_3 v_h] + c_2 [\delta_1 s_3 (v_t - v_h)] \\ \text{Numerical Check:} & = .08 + (.25)[.1333 + .0167] + (.67)(.03) \\ & .1375 = .08 + .0375 + .02 \end{aligned}$$

$$\begin{aligned} \text{Premium on Non-tradables:} &= [s_1 - f_1(s_1 + s_2)] \tau_m + c_1 [(s_1 + s_2) v_t + s_3 v_h] - c_2 [\delta_1 (s_1 + s_2) (v_t - v_h)] \\ \text{Numerical Check:} & = .02 + (.25)(.1333 + .0167) - .67[.6(.67)(.15)] \\ & .0175 = .02 + .0375 - .04 \end{aligned}$$

Note: $c_s = (1 - e_{is})$; $c_a = (1 - e_{ia})$.

Table 9B
Expressions for Premia on Tradables and Non-tradables
(Project Funds Sourced 100% abroad)

Table 9B simply codifies the results of Table 9.3, presenting general expressions for the premia, together with numerical checks to link the results to Table 9.3.

With Uniform Import Tariff (τ_m) Alone

Premium on Tradables	= zero
Premium on Non-tradables	= $-f_1 \tau_m$
Numerical check	$-.06 = -(0.5)(0.12)$

With Uniform Import Tariff (τ_m) Plus Value Added Taxes (v_t and v_h)
(No Credit for Investment)

Premium on Tradables	= zero
Premium on Non-tradables	= $-f_1 \tau_m - \delta_1 (v_t - v_h)$
Numerical Check	$-.15 = -(0.5)(0.12) - (0.6)(0.15)$

With Uniform Import Tariff (τ_m) Plus Value-Added Taxes (v_t and v_h)
With Credit for Investment

Premium on Tradables	= zero
Premium on Non-tradables	= $-f_1 \tau_m - c_a \delta_1 (v_t - v_h)$
Numerical Check	$-.12 = -(0.5)(0.12) - (0.67)(0.6)(0.15)$

Note: $c_s = (1 - e_{is})$; $c_a = (1 - e_{ia})$.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 10:**

ECONOMIC PRICES FOR TRADABLE GOODS AND SERVICES

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ABSTRACT

In the integrated financial and economic analysis, there is a need to choose a numeraire in which all costs and benefits are expressed. The most common practice has been to express all costs and benefits in terms of domestic currency at a domestic price level. This is the natural rule to follow for the construction of the financial cash flow statement of a project that includes all the financial receipts and all the expenditures in each period throughout the duration of the project. When this numeraire is chosen to carry out the economic appraisal of the project it is necessary, however, to adjust the values of the transactions in the financial cash flow that involve internationally tradable goods because of distortions associated with the transactions of these goods and those that affect the market for foreign exchange. This chapter identifies the key distinct characteristics between tradable and non-tradable goods and provides a method for adjusting the financial values of tradable goods so that they reflect their economic values.

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CHAPTER 10

ECONOMIC PRICES FOR TRADABLE GOODS AND SERVICES

10.1 Introduction

In the integrated financial and economic analysis, there is a need to choose a numeraire in which all costs and benefits are expressed. The most common practice has been to express all costs and benefits in terms of domestic currency at a domestic price level.¹ This is the natural rule to follow for the construction of the financial cash flow statement of a project that includes all the financial receipts and all the expenditures in each period throughout the duration of the project. When this numeraire is chosen to carry out the economic appraisal of the project it is necessary, however, to adjust the values of the transactions in the financial cash flow that involve internationally tradable goods because of distortions associated with the transactions of these goods and those that affect the market for foreign exchange.

Tradable goods or services can be either importable or exportable. In the case of importable goods that are transported from the border to the project site, it will undoubtedly involve additional non-tradable service charges for the project such as handling charges and transportation costs that are usually distorted in the market and thus the values must be adjusted in the economic evaluation. Likewise, for exportable goods where a project is considering producing their products to the export markets or using an exportable good as a project input, the financial value of the product (at factory gate) presented in the financial cash flow statement is generally determined in the world market and then net of port charges and transportation costs from the port to the domestic market. The costs of these non-tradable services are also distorted in the markets and adjustments must be made in deriving the net economic value of the project output or

¹ Some authors are concerned that doing the analysis in terms of domestic prices might not provide a sound evaluation of the projects. See Appendix 10A.

CHAPTER 10:

project input. The evaluation of these non-tradable services from the project site to the border will be dealt with in the following chapter.

Section 10.2 identifies the key economic characteristics of tradable and non-tradable goods. Section 10.3 describes how to integrate the financial values and various distortions into the economic evaluation of tradable goods. Section 10.4 provides a practical example how the economic values of various tradable project outputs and inputs can be measured. Conclusions are made in the last section.

10.2 Identification of Tradable Goods

To begin, we need to define the relationship between imported and importable goods, between exported and exportable goods, and between non-traded and potentially traded goods.

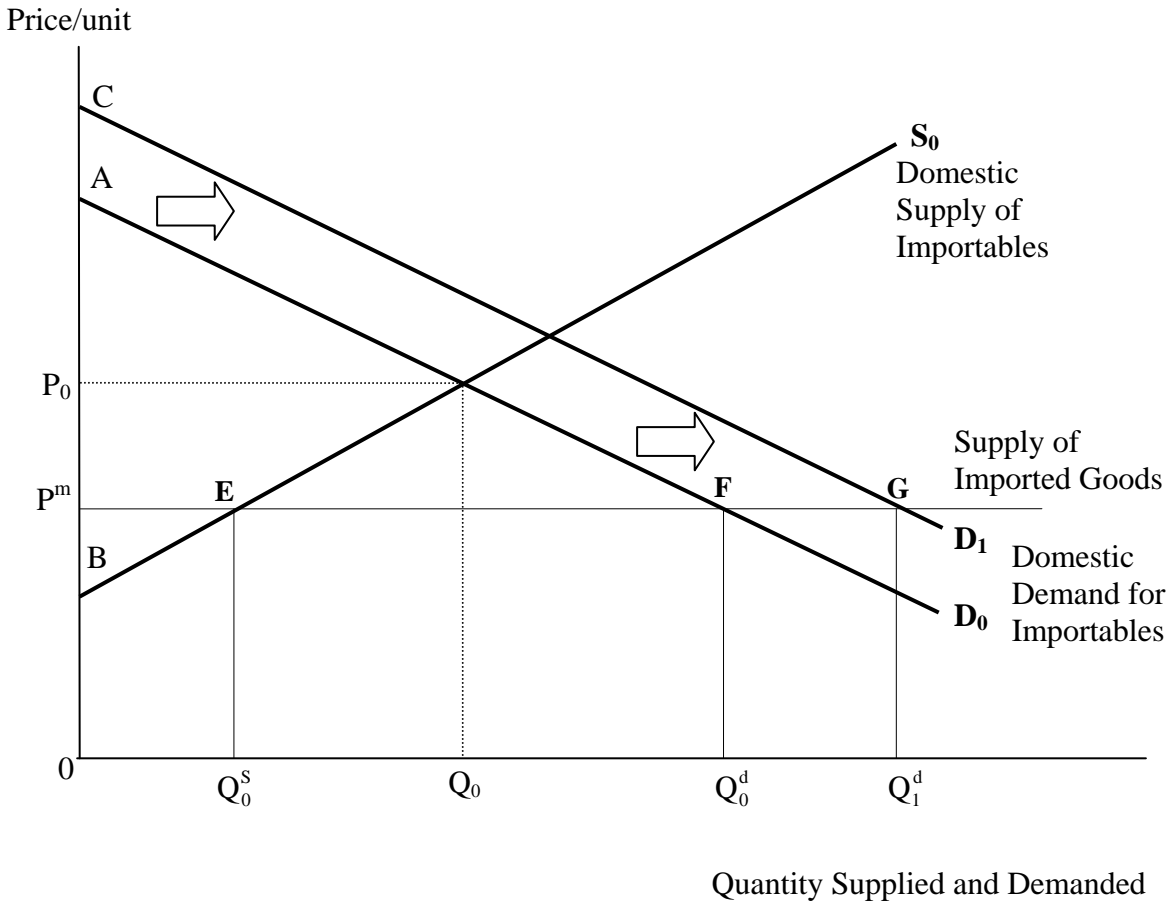
10.2.1 Imported and Importable Goods

Imported goods are produced in a foreign country but are sold domestically. Importable goods include imports plus all goods produced and sold domestically that are close substitutes for either imported or potentially imported goods. The relationship between importable and imported goods can be seen in Figure 10.1 for the case of an item such as power hand tools used as a project input. Suppose the items purchased by a project are manufactured locally. At the same time a significant quantity is also being imported. The demander's willingness to pay for this item is shown by the demand curve AD_0 while the domestic marginal cost of production is shown by the supply curve BS_0 . If all imports were prohibited, then the equilibrium price would be at P_0 and the quantity demanded and supplied would be at Q_0 .

Because imported goods can be purchased abroad and sold in the domestic market at a price of P^m which is equal to the cif price of imports converted into local currency by the

market exchange rate, plus any tariffs and taxes levied on imports. This price will place a ceiling on the amount domestic producers can charge and thus will determine both the quantity of domestic supply as well as the quantity demanded by consumers. When the market price is P^m , domestic producers will maximize their profits if they produce only Q_0^S because at this level of output they will be equating the market price with their marginal costs. On the other hand, demanders will want to purchase Q_0^d because it is at this quantity at which their demand price is just equal to the world-market-determined price P^m . The country's imports of the good measured by the amount $(Q_0^d - Q_0^S)$ are equal to the difference between what demanders demand and domestic producers supply at a price of P^m .

Figure 10.1: Imported and Importable Goods
-- The Case of Power Hand Tools Used as Project Input --

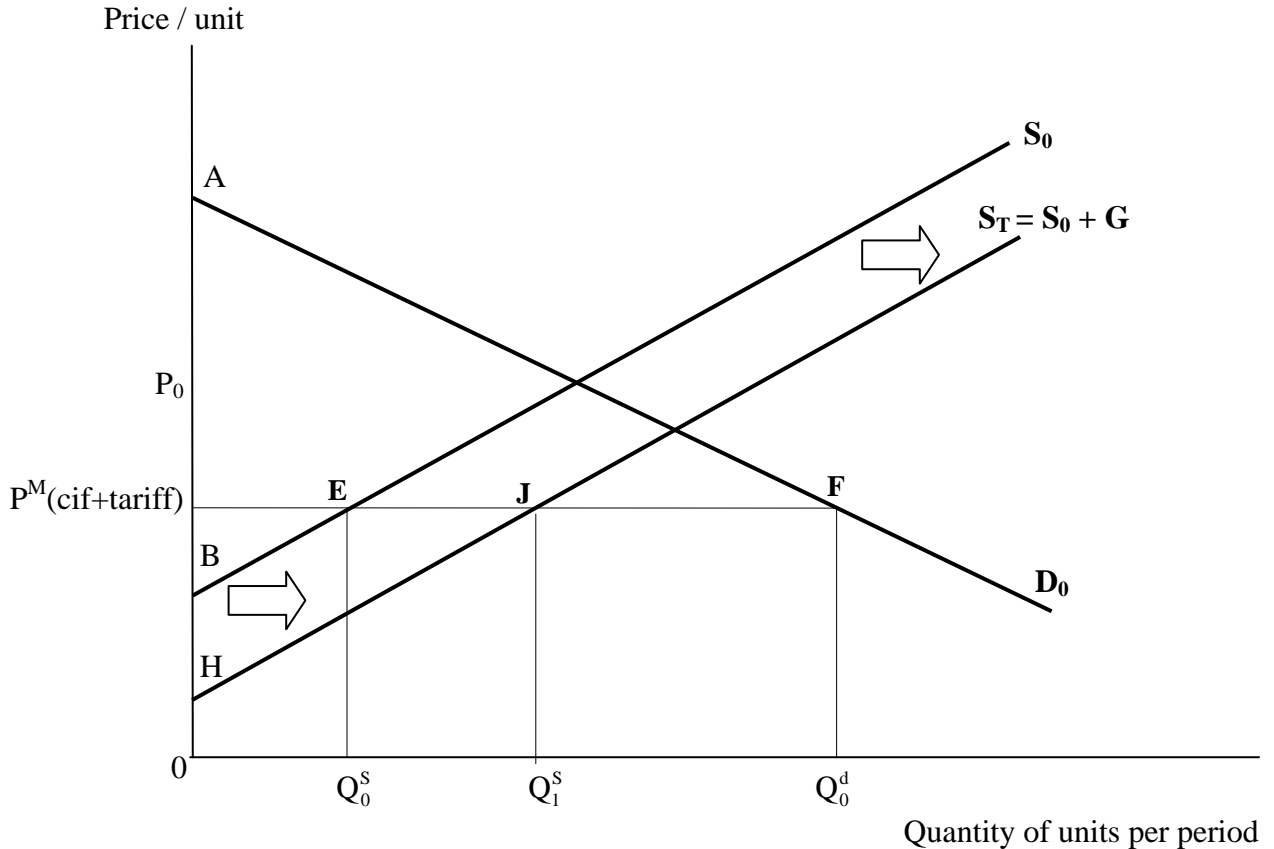


If a project now purchases the item as an input, this can be shown as a shift in its demand from AD_0 to CD_1 . Unlike a situation where there are no imports, the increase in demand does not cause the market price to rise. This is because a change in the demand for such a traded good in one country will in virtually all cases not lead to a perceptible change in the world price for the commodity. As long as the price of imports remains constant, the increase in the quantity demanded leaves the domestic supply of the good unaffected at Q_0^S . The ultimate effect of an increase in the demand for the importable good is to increase the quantity of imports by the full amount $(Q_1^d - Q_0^d)$. Thus, to evaluate the economic cost of an importable good, we need to only estimate the economic cost of the additional imports.

Likewise, the value of the benefits derived from a project which increases the domestic production of an importable good should be based entirely on the economic value of the resources saved by the decrease in purchases of imports. In Figure 10.2 we begin with the initial position shown by Figure 10.1 prior to the project's purchase of the item. A project to increase the domestic production of these goods will shift their domestic supply from BS_0 to HS_T . This increase in domestic supply does not result in a fall in price, but rather a decrease in imports, as people now switch their purchases from imported items to the domestically produced ones.

Unless the project is big enough to completely eliminate all imports of the item, the domestic price will be pegged to the price of imports and thus, the domestic demand for the input by other domestic consumers will not be changed. Imports will fall from $(Q_0^d - Q_0^S)$ to $(Q_0^d - Q_1^S)$, an amount equal to the output of the project $(Q_1^S - Q_0^S)$. As domestic production serves as a one-for-one substitute for imported goods, the economic value of the resources saved by the reduction in the level of imports measures the economic value of the benefits generated by the project.

Figure 10.2 Imported and Importable Goods
-- The Case of Power Hand Tools Produced Domestically --



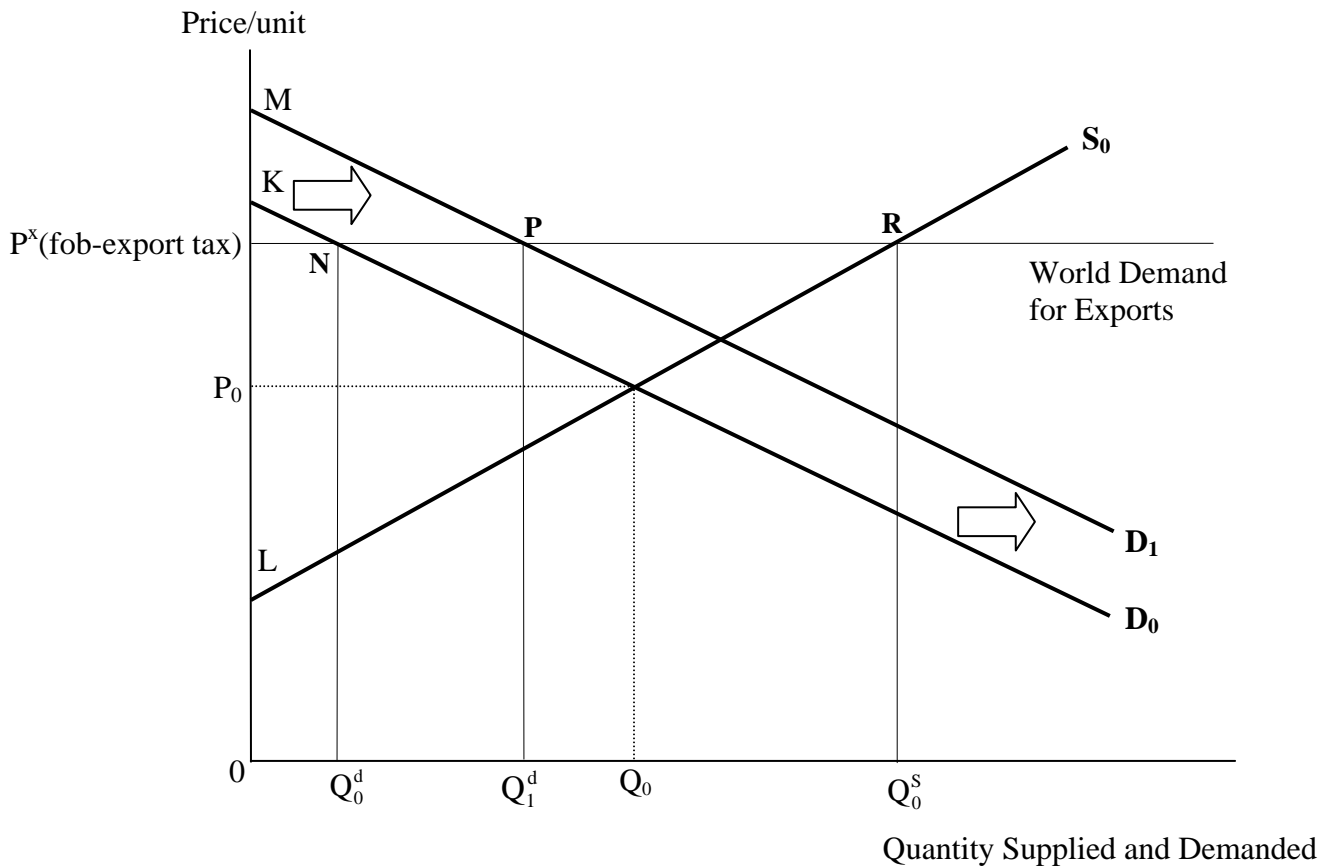
10.2.2 Exported and Exportable Goods

Exported goods are produced domestically but sold abroad. Exportable goods include both exported goods as well as the domestic consumption of goods of the same type or close substitutes to the goods being exported. The relationship between exportable and exported goods is very similar to that of importable and imported goods. In Figure 10.3 the demand for an exportable good is shown as KD_0 and the domestic supply of the exportable good is denoted by LS_0 .

If the domestic production of timber in this country could not be exported, then domestic supply and demand (Q_0) would come into equilibrium at a price of P_0 . However, the

commodity will be exportable so long as the domestic market price P^x (i.e., the fob price times the market exchange rate less export taxes), which domestic suppliers receive when they export, is greater than P_0 . If, for example, producers receive a price of P^x (see Figure 10.3), timber production will amount to Q_0^S . At this price, domestic demand for timber is only Q_0^d , hence, a quantity equal to $(Q_0^S - Q_0^d)$ will be exported.

Figure 10.3 Exported and Exportable Goods
-- The Case of Timber Used by Project --



We now introduce a project, which requires timber as an input, shifting the demand for this exportable good from KD_0 to MD_1 . Total domestic demand will now be equal to Q_1^d leaving only $(Q_0^S - Q_1^d)$ available to be exported. P^x will remain constant so long as the world price is not altered by the change in demand due to the project. No changes in incentives have been created which would lead to an increase or decrease in domestic

supply. The measurement of the economic cost of this input to the project should be based on the economic value of the foreign exchange that is forgone when the $(Q_1^d - Q_0^d)$ units of timber are no longer exported.

As the market price is fixed by the world price, the benefit of a project that produces such an exportable good should be measured by the value of the extra foreign exchange that is produced when the project's output is reflected in increased exports, while the costs entailed in a project's demanding more of the exportable will be measured by the economic opportunity cost (value) of the foreign exchange forgone.

All importable and exportable goods should be classified as tradable goods. Although an input might be purchased from a domestic supplier for a project, as long as it is of a type similar to ones being imported it is an importable good and should be classified as tradable. Likewise, goods if domestically produced and used as project inputs, which are similar to exported goods,² are exportable goods and are also included in tradable goods.

10.3 Economic Values for Tradable Goods and Services

10.3.1 The Essential Features of an Economic Analysis

The distinguishing feature of tradable goods is that changes in their demand or supply end up being reflected in the demand for or supply of foreign exchange. A project that produces more of an importable good will reduce the demand for (and therefore the amount of) imports of that good; thus reducing the demand for foreign exchange.

² It is reasonable to ask whether one should not also include an in-between category of "semi-tradables". These would, by and large, be goods whose price is influenced but not totally determined by external world-market forces. Product differentiation between imports and import substitutes, and between exports and export substitutes would of course be the principal element defining the in-between category. It is our view that the insertion of a category of "semi-tradables" would further substantially complicate an analytical framework that is a daunting challenge to most countries (to develop a large cadre of practitioners capable of seriously applying it in practice). Our preference is, therefore, to stick with a sharp distinction between tradables and non-tradables. The aim would be to classify some "semi-tradables" as full

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Similarly, a project that produces more of an exportable good will ultimately add to the supply of exports and hence of foreign currency. Thus the principal benefit of either type of project is to make additional foreign exchange available “for general use”. To value this foreign exchange, we use the concept of the “economic opportunity cost of foreign exchange” (EOCFX), which states, in terms of a domestic-currency numeraire, the real economic value (in a peso or rupee country) of an incremental real dollar of foreign exchange. We dealt with the precise measurement of EOCFX in Chapter 9. Here it is sufficient to note (a) that it is different from the real exchange rate E_m that is reflected in the market foreign exchange, (b) that part of the difference reflects the tariff and indirect tax revenue that is given up when additional foreign exchange is extracted from the market, and (c) that another part of the difference reflects the tax and tariff revenue that is given up when raising the pesos or rupees that are spent in acquiring that foreign exchange.

For the present, we will operate under the assumption that the EOCFX exceeds E_m so that there is a positive premium on foreign exchange. Our present task is to inquire in what ways we should deal with tariffs, taxes, and other possible distortions that are in some sense “specific” to the project we are analyzing.

A good guide to thinking about this subject is to consider a case in which the project authority has borrowed rupees in the capital market, and then going into the foreign exchange market to buy dollars -- only to have those dollars incinerated by an accidental fire. The economy has lost, as a consequence of that accident, the economic opportunity cost of foreign exchange. This should be obvious.

But from this example, we can learn something that is not so obvious. The EOCFX does not include any item that has anything to do with the use or uses to which that foreign exchange may be put, (e.g., by importing goods with high, medium, low or zero import

tradables, thus committing errors in one direction, which one hopes would tend to be substantially offset by classifying other semi-tradables as non-tradables, thus committing errors in the opposite direction.

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duties) or with the specific distortions that might affect projects that end up generating foreign exchange (e.g., by producing export goods subject to either export taxes or subsidies).

If, then we use foreign exchange to buy an import good M_j that is subject to a tariff T_j , we should consider the extra tariff revenue to be a project benefit (i.e., a financial but not an economic cost). It is also the same if we buy the same type of good from a domestic producer of it, because in the end our demand will lead to somebody else increasing imports of M_j by a like amount.

If our project generates foreign exchange by producing an export good X_i , subject to an export tax T_i , the extra tax revenue generated from these exports should be considered as an economic benefit, on top of the economic premium on the foreign exchange that the project generates. Here again, the benefit calculation would be the same if the project produced an equivalent exportable good, that happened to be sold to domestic demanders. For in this case, too, those demanders turning to our project to meet their demand implies that an equivalent amount that would have been taken by these demanders in the scenario “without” our project will now be available for export.

Import tariff rates applied to project inputs of importable goods, and export tax rates applied to the project outputs of exportable goods, are thus to be explicitly counted as project benefits. In the first case the financial cost is greater than the economic cost by the amount of the tariff, but the economic cost must be calculated inclusive of the cost of the foreign exchange premium. In the case of the exportable output, its economic value as reflected by its fob price is greater than the financial price, by the amount of the tax. In this case the economic price must be calculated inclusive of the foreign exchange premium. The story is reversed when it comes to project inputs of exportable goods or project outputs of importable goods. For when an exportable good is used by our project, less is exported and the government loses the potential export tax. And when an

importable good is produced by our project, the natural consequence is that less of that good will be imported, with a corresponding loss of tariff revenue.

Another way of stating the same case is that when we use an import good, we probably pay a domestic financial price equal to the world price plus the tariff. But the tariff part is simply a transfer to the government, hence should be eliminated as a component of our cost. Likewise, when we produce an export good subject to export tax, financial accounts will incorporate our receipts net of tax, but the tax is not a cost from the standpoint of the economy. As a whole, the import tariff or the export tax should be eliminated (as a cost) as we move from the financial to the economic cost-benefit exercise.

10.3.2 The Valuation of Tradable Goods at the Border and the Project Site

The economic evaluation of traded outputs and inputs is done in a two stage process. First, the components of the financial cost of the import or export of the good that represent resource costs or benefits are separated from the tariffs, taxes, subsidies, and other distortions that may exist in the market for the item. Second, the financial value of the foreign exchange associated with the net change in the traded goods is adjusted to reflect its economic value and is expressed in terms of the general price level (our numeraire).³ The evaluation of projects expressed in terms of the domestic level of prices is also for the comparability of the results between the financial and economic appraisal.

³ Alternatively, one could use an international price level (P^w) as the numeraire. To do this one would adjust the value of non-tradable goods by the reciprocal of the same factor which is used to express the foreign exchange content of the project in terms of the general price level. Although some authors (see Little and Mirrlees, etc.) have advocated carrying out the full analysis of a project's costs and benefits in terms of foreign currency (e.g., US dollars or Euros), practitioners have found it very awkward to generate international prices for commonplace items like haircuts, taxi rides and gardeners' services. If two projects from different countries (e.g., Argentina and India) have to be compared to each other, it is easy to bring them to common terms by taking the net present value of the Argentine project (in real pesos) and multiplying it by the real exchange rate measure (real dollars per real peso). Similarly, one would correct the Indian project's net present value (in real rupees) into real dollars by multiplying it by a measure of real dollars per real rupee. Once both NPV are thus converted to real dollars, they are fully comparable. The need, however, for such comparison is rare. It is insignificant as compared to the desirability of carrying

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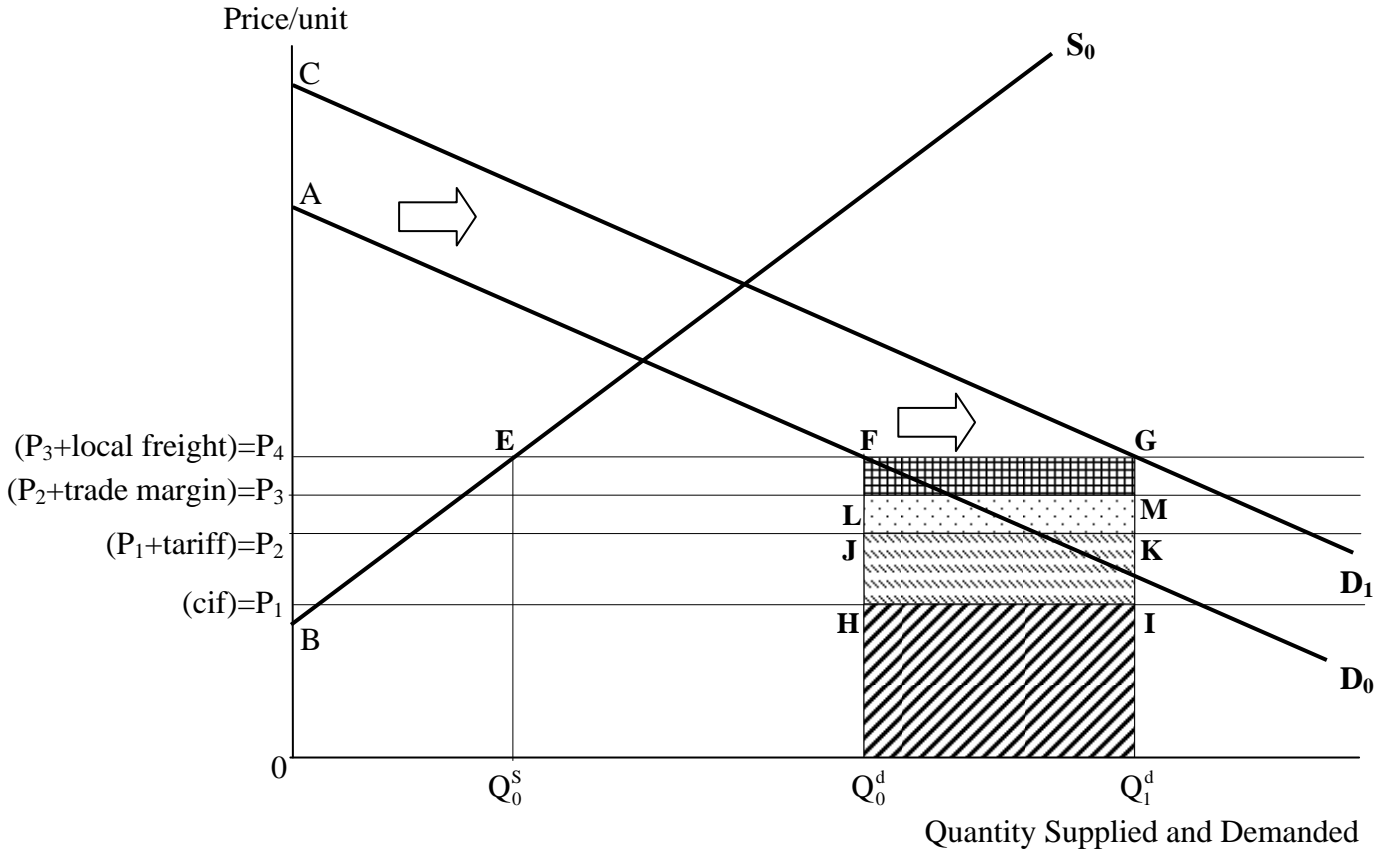
In the discussion that follows we first undertake the analysis for a country where there is no premium on foreign exchange. The economic evaluation of tradable goods is then carried out for the case where there is a premium on foreign exchange. These adjustments are built into the calculation of economic value of the tradable goods and services. Following these estimations, commodity specific conversion factors are constructed for transforming financial prices into economic values at the border.

Importable Goods

The financial cost of an importable input for a project can be equated to the sum of four components of the cost of an imported good, i.e., the cif price of the imported good, tariffs/taxes and subsidies, the trade margins of importers, and the costs of freight and transportation costs from the port to the project. The sum of these four items will be approximately equal to the delivered price of the input to the project, both when the good is actually directly imported and when it is produced by a local supplier. This can be illustrated in Figure 10.4. The ultimate effect of an increase in the demand for an importable good by a project is to increase imports by $(Q_1^d - Q_0^d)$. The domestic value of the foreign exchange required to purchase these goods is equal to the cif price (P_1) times the quantity $(Q_1^d - Q_0^d)$ as denoted by the shaded area $Q_0^d H I Q_1^d$. This is part of the economic resource cost of the input because the country will have to give up real resources to the foreign supplier in order to purchase the good.

out the actual computations in real terms, in domestic currency, a procedure which is virtually required if a serious analysis of stakeholder interests is to be done.

**Figure 10.4: Economic Cost of Importable Goods
-- The Case of Power Hand Tools Used by a Project --**



Tariffs are often levied on the cif price of the imported good by the importing country. These tariffs are a financial cost to the project but are not a cost to the economy, because they only involve a transfer of income from the demanders to the government. Therefore, tariffs and other indirect taxes levied on the imported good should not be included in its economic price.

The importer and perhaps the traders are involved in the process which brings the item from the foreign country to the final delivery at the project site. There are a number of tasks including handling, distribution and storage for which the traders receive compensation. These are referred to as the trading margin. Over and above the trade

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margin there are the freight costs incurred by the importer or traders to bring the item from the port or border entry point to the project.

The trading margins are part of the economic costs of the imported good. The financial value of the trade margin may in some cases be larger than the economic cost of the resources expended. The most obvious case of this occurs when the privilege to import a good is restricted to a few individuals through the selective issuing of import licenses. In this case the importer may be able to increase the price of the imported good significantly above the costs he incurs in importing and distributing the item. These excess profits are not a part of the economic cost to the country of the imported good as they represent only income transfers from the demanders of the imports to the privileged people who obtained the import licenses. Therefore, while the financial trading margins of the traders are shown as the difference in the prices ($P_3 - P_2$) or the area JLMK in Figure 10.4 the economic cost may be less than this by the proportion of the total trade margin which is made up of “monopoly profits”.

Because freight costs may vary greatly with the location of the project in the country, it is advisable to treat these costs as a separate input. Because this sector uses items that are often heavily taxed -- such as petroleum products and motor vehicles -- as inputs, its economic costs might be significantly less than its financial cost.⁴ If we are to compare the economic cost of an importable input with its financial price, the former will consist of the cif price plus the economic cost of the traders’ services, plus the economic cost of the freight and transportation required to bring an importable good from the port to the project.

Table 10.1 shows the breakdown of the financial cost of an imported car. In this case the economic cost of the car is \$24,400, while its financial cost is \$37,600. This same

⁴ It is more accurate to break the local freight costs down into different component costs and then calculate their economic costs.

evaluation of the economic price of a car also holds if instead we wish to measure the economic benefit of producing cars locally.

**Table 10.1 The Estimation of Economic Cost of Importable Input:
The Case of Cars**

<u>Financial Cost of Imported Car</u>		<u>Economic Cost of Imported Car</u>	
CIF Price	\$20,000.00		\$20,000.00
Tariff (45% of cif)	9,000.00		-
Sales tax (10.0% of cif)	2,000.00		-
Trade margin (30.0%)	6,000.00	(66.7% of financial cost)	4,000.00
Freight	600.00	(66.7% of financial cost)	400.00
	-----		-----
Total	37,600.00		24,400.00

We find that the ultimate effect of increasing the domestic production of a traded input is to reduce imports. The economic benefit of such an endeavor is the economic resources saved from the reduced imports. In the above example, we would expect that a domestic producer of cars will be able to charge a price for a car of \$37,600 including taxes and freight. However, the economic resources saved are equal to only \$24,400. It is this amount which is equal to the economic value of a unit of domestic car production. Note that a domestically produced car, with costs equal to, say, \$30,000 would be a smashing financial success, but in order to make it economically advisable to produce cars domestically, they should (in this example) have economic costs less than or equal to \$24,400. If a car that was domestically produced at the project site had costs of \$24,000, it would be able to compete with the imported model, even if subject to an excise tax of 45% on its full economic cost of \$24,000, plus a sales tax of 10% on the same base. These together would lead to a financial “price” of \$37,200. This example shows how a protective tariff can lead to inefficient domestic production (the case of a car with economic costs of \$30,000), and how such inefficiency would be avoided with an equivalent tax treatment of cars, regardless of where they are produced.

The general rule is that before adjusting for the economic price of foreign exchange, the economic value of importable good production at the factory site is equal to the cif price plus the economic cost of local freight from port to national market and then minus the economic cost of local freight from the project site to the market. By the way of comparison, the economic cost of imported inputs is calculated as the sum of the cif price at the port plus the economic cost of freight from port to the project site.

Exportable Goods

Exportable goods, which are used as inputs in a project, typically have a financial price that is made up of the price paid to the producer, taxes, freight and handling costs. However, it is not these items which are adjusted to measure the economic cost of the item. It is the economic benefits foregone by reduced exports, which is the measure of economic cost for such an input. The country forgoes the world price (fob at the port), when a new project buys items that would otherwise be exported. This part of the cost is not altered by the presence of export taxes or subsidies -- these simply create differences between the internal price and the fob price, domestic selling price at the port being higher than the fob price in the case of an export subsidy, and lower in the case of export tax.

Adjustments should be made however for freight and handling charges. To obtain the economic benefit foregone by using an exportable good domestically, we begin with the fob price and deduct the economic costs of the freight and the port handling charges, as these are saved when the goods are no longer exported, but we add the economic costs of freight and handling charges incurred in transporting the goods to the project. This is illustrated in the case of timber in Table 10.2.

As shown in Table 10.2, the financial cost of the timber to the project site is \$495 which is made up of a \$500 producer price (fob price of \$400 plus export subsidy of \$100) less

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a financial cost differential for transportation of \$50 (\$125 saved plus \$75 newly incurred) plus a domestic sales tax of \$45. Any use of this exportable timber as an input to a local project has an economic cost of \$360 which is the fob price of \$400 less the economic cost of the freight and handling charges saved of \$100 on the forgone timber exports plus the economic costs of the freight and handling in shipping the timber to the project site of \$60. The assumption made here is that economic cost of freight and handling is 80% of its financial cost.

Moreover, the economic prices for tradable goods at the port should include adjustment for foreign exchange premium while at the project, they should also include the premium on outlays made to non-traded goods and services such as handling charges and transportation costs.

**Table 10.2 Economic Cost of Exportable Good:
-- The Case of Timber Used by a Project --**

<u>Financial Cost of Timber</u>		<u>Economic Cost of Timber</u>	
Fob price	\$400.00	Fob price	\$400.00
plus export subsidy	<u>100.00</u>	less economic cost of	
Producer price	500.00	freight/handling costs,	100.00
		market to port	
less freight and handling,	-125.00	plus economic cost of freight	
market to port		and handling, market to	60.00
plus freight and handling,		project	
market to project	<u>+ 75.00</u>		
	\$450.00		
plus domestic sales tax 10%	<u>45.00</u>	Total	\$360.00
Total	495.00		

10.3.3 Conversion Factors for Tradable Goods at the Border and the Project Site

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The economic prices of tradable goods account for the real resources consumed or products produced by a project and hence are not the same as the prices (gross of tariffs and sales taxes) paid by demanders, or the prices (gross of subsidies and net of export taxes) received by suppliers. These latter “paid or received” prices are what we designate as financial prices. However, import tariffs and sales taxes or export taxes and subsidies associated with the importable or exportable goods are simply a transfer between the government and importers or exporters, they are not part of the economic cost or benefit.

A conversion factor (CF) is defined as the ratio of a commodity’s economic price to its financial price. The value of the conversion factor for the importable good i (CF_i) at the port is the commodity’s economic price (EP_i) at the port divided by its financial price (FP_i) at the port. Suppose that there are tariffs and other indirect taxes such as VAT levied on the i th good at the rates of t_i and d_i , respectively. Also, the foreign exchange premium for the country in question is FEP. The CF_i can then be calculated and expressed as:

$$\begin{aligned} CF_i &= EP_i/FP_i \\ &= (1 + FEP)/[(1 + t_i)(1 + d_i)] \end{aligned} \quad (10.1)$$

A similar formula can also be used for exportable goods in which indirect taxes are usually exempt of exports. Thus, CF_j for the j th exportable good can be calculated as follows:

$$\begin{aligned} CF_j &= EP_j/FP_j \\ &= (1 + FEP)/(1 + k_j) \end{aligned} \quad (10.2)$$

where k_j stands for the subsidy (or a negative value for export tax) rate of the fob price.

The conversion factor has the feature of being convenient, in that these ratios can be applied directly to convert a financial cash flow into an economic cost or benefit as we

move from a project's financial cash flow statement to its economic benefit and cost statement. It should be noted that the above conversion factor does not incorporate any location-specific domestic handling and transportation costs from the port to the project site. When the adjustment for the impact on the economic costs of these non-tradable services for the item is made, one can obtain the economic value and the conversion factor for the tradable goods at the project site, which will be easily incorporated as part of the total economic costs or benefits of the project.

10.4 An Illustrative Example

There are four possible cases that can be applied to measuring the economic values of tradable goods. They include: an importable good is used as an input to a project, an importable good is produced by a domestic supplier, an exportable good is produced by a domestic supplier, and an exportable good is used as an input by a project. Examples provided below illustrate how each of the economic values and the corresponding conversion factors of various output and inputs of an irrigation project in Visayas of the Philippines are estimated.⁵ The goal of the project was to alleviate poverty while improving environmental sustainability of the region. The foreign exchange premium (FEP) was estimated at 24.60%.

a) Project Uses an Importable Input (Pesticides)

In order to improve the farm's productivity, the project requires pesticides that are importable. The financial prices of pesticides at the border include the cif cost of the imported item plus additional costs levied on the item such as tariff. The cif border price is US\$ 166.00 per 1000 liters that is equal to 4,038 pesos when converted by the market exchange rate. This plus tariff imposed on the item upon arrival at the port of Manila determines the financial prices. There is 5 percent tariff rate on imported pesticides. Thus,

⁵ Jenkins, Glenn P. Pastor, Lorenzo, and Therasa, Panuccio, "Farmer Participation, a Key Input to Success: The Visayas Communal Irrigation Project", Harvard Institute for International Development, (December, 1994).

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the financial cost in Manila will become 4,239 pesos at the port. However, the economic cost of this imported item will include only the cif cost that must be adjusted by the foreign exchange premium to reflect the true cost of this input. The tariff is considered a transfer within the economy and do not represent the real economic resources used. The conversion factor (CF) for pesticides in this case is 1.19 at the port, which is calculated either by the ratio of the economic to the financial costs of the pesticides as presented in Table 10.3 or by equation (10.1).

Table 10.3
Project Uses Importable Pesticides

	Financial Price	Conversion Factor for Nontradable Services	Value of FEP	Economic Value
CIF World Price per 1000 liters of pesticides				
US Dollars	166.00			
Local Currency	4,038.00		993.35	5,031.35
PLUS				
Tariff	201.00			0
Price at Port	4,239.00			5,031.35
CF at the Port	1.19			
PLUS				
Handling/Transportation from Port to Manila				
Handling	540.00	0.90		486.00
Transportation	225.00	1.20		270.00
PLUS				
Traders' Margin	200	0.7		140.00
PLUS				
Handling/Transportation from Manila to Farm Gate				
Handling	600.00	0.90		540.00
Transportation	250.00	1.20		300.00
Price at the Farm Gate	6,054.00			6,767.35
CF at the Project Site	1.12			

In order to find the cost of pesticide delivered to the farm gate, farmers incur additional costs of trading, handling and transportation from the port to Manila, the main trading center, and from Manila to the local market and then to the project site. By adding all

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these costs as presented in the second column of Table 10.3, farmers will pay a total of 6,054 pesos for getting 1,000 liters of pesticides to their farm gate.

The economic cost of each of the above domestic services differs from its financial cost because of various distortions involved. Estimation of these non-tradable services will be fully discussed in Chapter 11. At present, the conversion factor is assumed to be estimated at 0.70 for traders' margins and 0.90 for handling charges. In the case of transportation services, the conversion factor is assumed for 1.20 due to a subsidy provided to the transportation producers. As a result, the economic cost for getting 1000 liters of pesticides at the project site amounts to 6,767 pesos and the conversion factor is estimated at 1.12 for pesticides. This indicates that, at the farm gate, the true economic cost of pesticides is 12 percent greater than the financial price suggests.

b) Project Produces an Import-Substitute Output (Rice)

Rice is one of the two major traded crops produced under the project for the consumption in the Philippines. The project's production is a substitute for imported rice. The price the farmers receive for its product depends on the world rice price. Suppose that the cif price for rice is US\$ 314.80 per metric ton at Manila's port. Expressed in units of domestic currency it becomes 7,659 pesos per metric ton of rice. In this case, there is no import tariff or taxes levied on rice. Thus, the rice produced by the farmer could not be sold at the port for more than 7,659 pesos per metric ton while the economic value will be measured by the economic foreign exchange saved at 9,543 pesos. Thus, the conversion factor for rice is 1.25.

The traders' margins, handling and transportation costs from the port to the market in Manila will be added and the corresponding costs for the local production will be subtracted in order to arrive at the farm gate price. Since rice is a substitute good, merchants in Manila market would not pay more for the rice produced domestically from the farmers than what they pay for imported rice, which is 8,281 pesos. To find the

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financial price of paddy the farmers produce, they have to incur additional expenses for milling, trading, handling and transportation costs as shown in the second column of Table 10.4. In addition, it should be noted that paddy is about 65% equivalent for rice. As a consequence, the financial price of paddy at the farm gate will be 4,501 pesos.

To derive the economic value of paddy farmers produce, the financial costs of the above services must be adjusted using the respective conversion factors estimated. After all these adjustments have been made, the total economic value of paddy will be 5,601 pesos per metric ton and the conversion factor import-substituted rice would be 1.24. Thus, the economic analysis indicates that at the farm gate, the true economic value of rice is worth about 24 percent more than the financial price suggests.

Table 10.4
Project Supplies Domestically Importable Rice

	Financial Price	Conversion Factor for Nontradable Services	Value of FEP	Economic Value
CIF World Price per ton of Rice				
US Dollars	314.80			
Local Currency	7,659.00		1,884.11	9,543.11
CF at the Port	1.25			
PLUS				
Transportation/Handling Charges Port-Manila				
Handling	50.00	0.90		45.00
Transportation	100.00	1.20		120.00
Traders' Margin	472.00	0.70		330.40
Wholesale Price in Manila	8,281.00			10,038.51
LESS Transportation from Rice Mill to Manila	515.00	1.20		618.00
Ex-Mill Price of Rice	7,766.00			9,420.51
LESS Milling Cost	345.00	1.10		379.50
Pre Milled Value	7,421.00			9,041.01
Paddy Equivalent (65%)	4,823.65			5,876.66
LESS				
Grain Dealer's Margin (4%)	192.95	0.70		135.06
Handling/Transport from Farm to Mill				
Handling	50.00	0.90		45.00
Transportation	80.00	1.20		96.00
Price of Paddy at Farm Gate	4,500.70			5,600.60
CF at the Project Site	1.24			

c) An Exportable Good (Seeds) is Produced by a Project

Seeds are produced domestically at the International Rice Research Institute (IRRI) in Manila. Suppose that the Institute is considering increasing their production of seeds and exported to the foreign markets. The financial price in domestic currency for seeds will be determined by the fob price of seeds at Manila port that is the world price of US\$ 410, or 9,975 pesos per ton. If the government provides export subsidy on seeds, its financial revenue of seeds will increase by an equivalent amount. Suppose in this case there is an export subsidy of 10% of the sale price of those seeds sold abroad. IRRI will not sell seeds to domestic buyers for less than the fob price plus the subsidy of 998 pesos per ton or 10,973 pesos net of port charges and transportation cost from Manila port to the IRRI.

The economic price of the exported product is determined by the fob price and augmented by the foreign exchange premium to reflect the true value of this output. Thus, the economic value of exportable seeds equals 12,429 pesos at the border. As a result, the conversion factor of the exportable seeds at port is estimated at 1.13 as presented in Table 10.5.⁶

Table 10.5
Project Supplies Exportable Seeds
(assuming export subsidy)

	Financial Price	Conversion Factor for Nontradable Services	Value of FEP	Economic Value
FOB Price per ton of Seeds				
US Dollars	410.00			
Local Currency	9,975.00		2,454.00	12,429.00
PLUS				
Export Subsidy (10% of FOB Price)	998.00			

⁶ If the government instead levied an export tax on seeds at 10% of the fob price, the domestic price at the port would fall to 8,978 pesos. The conversion factor would have become 1.38 according to equation (10.2).

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Price at the Port	10,973.00			12,429.00
CF at the Port	1.13			
LESS				
Handling/Transportation Charges from IRRRI to Port				
Handling	120.00	0.90		108.00
Transportation	50.00	1.20		60.00
Price at IRRRI Gate	10,803.00			12,261.00
CF at the Project Site	1.14			

Suppose that the output of the IRRRI increases and the additional output does not affect the world price of the seeds, its economic price delivered to the port is measured by the fob price of the good multiplied by the market exchange rate. The fob price will be equal to the price received by the producer plus the financial costs of handling and transportation from the IRRRI to the point of export. The economic price of seeds at the IRRRI will be the fob price minus the economic costs of handling and transportation from the port to the IRRRI. To arrive at the economic values of these costs, the transportation and handling charges are adjusted for the distortions using the respected conversion factors estimated. The total adjusted economic value of exportable seeds at the factory gate of the IRRRI is equal to 12,261 pesos and the conversion factor becomes 1.14.

d) Project Uses an Exportable Good (Seeds) as a Project Input

Suppose that seeds produced domestically is an exportable good and is purchased as an input to the project rather than exported abroad. If seeds can be sold for \$ 410 a ton on the world market, the financial price in domestic currency at the port will be 9,975 pesos per ton. Suppose in this case there is an export subsidy of 10% of the sale price of those seeds sold abroad. In this case seeds will not be sold to domestic buyers for less than 10,973 pesos.

As the seeds is used by the farmers, rather than exported, the amount of foreign exchange gained by exporting the seeds is lost and thus the economic cost will be the cost of foreign exchange earnings forgone. The economic value must be adjusted for the foreign exchange premium to become 12,429 pesos, which results in a conversion factor of 1.13 as shown in Table 10.6.

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Seeds can be sold on the world market for a fob price of 9,975 pesos. However, the IRRI receives 10,803 pesos since it incurs 170 pesos for the transportation and handling charges from the IRRI to the port and receives 998 pesos for export subsidy. The Institute will not sell rice farmers for less than this amount. In addition, it will have to pay the local dealer's margin (370 pesos), plus transportation costs from IRRI to their farm (635 pesos). There are no taxes levied on seeds in the Philippines, so the total cost the farmers pay for their seeds amounts to 11,808 pesos per ton at the farm gate.

The total economic value of seeds at the farm gate needs to be measured in cost of the resources used in handling, transporting and marketing the good. As these activities are nontradable services, the economic value must be adjusted from the financial cost using the respective conversion factor. The final economic cost of 13,282 pesos for exportable seeds results in a conversion factor of 1.12.

Table 10.6
Project Uses Exportable Seeds
(assuming export subsidy of 10%)

	Financial Price	Conversion Factor for Nontradable Services	Value of FEP	Economic Value
FOB Price per ton of Seeds				
US Dollars	410.00			
Local Currency	9,975.00		2,454.00	12,429.00
PLUS				
Export Subsidy (10% of FOB Price)	998.00			
Price at the Port	10,973.00			12,429.00
CF at the Port	1.13			
LESS				
Handling/Transportation Charges from IRRI to Port				
Handling	120.00	0.90		108.00
Transportation	50.00	1.20		60.00
PLUS Dealers' Margin	370.00	0.70		259.00
PLUS Transportation Cost from IRRI to Farm	635.00	1.20		762.00
Price at Farm Gate	11,808.00			13,282.00
CF at the Project Site	1.12			

Expressing the relationship between the economic and financial prices of an item in this way is convenient as long as the underlying tariff, tax and subsidy distortions do not change in percentage terms, the value of the conversion factor will not be affected by inflation. Similarly, if a series of project evaluations are carried out, some of the conversion factors used for the analysis of one project may be directly applicable to others.

10.5 Conclusion

This chapter began with the identification of the key distinct characteristics between tradable and non-tradable goods. It is important to point out that the fundamental forces to determine either their financial or economic prices are different. In the case of tradable goods, they are defined to include not only exported or imported goods but also domestically consumed or produced goods so long as they are close substitutes for exported or imported goods.

The various distortions associated with tradable goods were then identified such as import tariffs, non-tariff barriers, export taxes, subsidies, value added tax and other indirect taxes. These distortions will have a considerable influence on the financial prices of the goods in the market. However, determining the economic prices of tradable goods and services is their world price since the world price reflects their economic opportunity cost or resources saved by the economy.

The economic prices of tradable goods can be estimated from the corresponding financial prices shown in the financial cash flow statement multiplied by the applicable commodity-specific conversion factors. The magnitudes of these conversion factors at the border depend upon the size of various distortions associated with the goods in question as well as the foreign exchange premium. When the tradable goods used or produced by the project are located away from the border, non-tradable services such as handling and

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transportation costs, trading margins, etc. are required by the project and their conversion factors must be estimated and incorporated in the analysis. Their financial and economic costs at the project site should be both properly assessed and estimated in the financial and economic appraisal of the project.

Appendix 10A

Evaluating Projects Subject to Trade Protection

One of the reasons why some authors (esp. Little, Little and Mirrlees) chose to recommend conducting the evaluation of development projects in terms of foreign currency and at “world” prices was their fear that doing the analysis in terms of domestic prices would lead to the likely approval of projects that were economically unsound, and that were made financially viable only due to protectionist measures. In this appendix we show, using numerical examples that our analytical framework is not subject to this criticism. It will catch unsound projects without fail.

Consider first a project to produce an import substitute for men’s shirts, whose external price is \$20. The market exchange rate is 10 rupees to the dollar, and the foreign exchange premium is 10 percent. With a 30 percent tariff on men’s shirts, the internal price of shirts will be Rs. 260. We here assume that our project is able to produce equivalent shirts domestically for Rs. 240 (including a normal return to capital). The project is thus viable from a financial point of view. However, it does not pass the test of an economic evaluation.

Selling price	=	Rs. 260
Reduced by 30 percent tariff (lost revenue to government)		<u> - 60</u>
		Rs. 200
Augmented by 10% foreign Exchange premium		<u> +20</u>
Equals economic benefit		Rs. 220
Actual cost of domestic production		<u> Rs. 240</u>
Net economic gain (+) or loss (-)		-Rs. 20

Consider next the case of an item subject to a 30 percent export subsidy, under the same conditions.

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World price (= \$20) at market exchange rate	= Rs. 200
Selling price with 30% export subsidy	= Rs. 260
Reduced by 30 percent export subsidy (extra outlay by government)	<u>-60</u>
	Rs 200
Augmented by 10% foreign exchange premium	<u>+20</u>
Equals economic benefit	Rs 220
Actual cost of domestic production	<u>Rs 240</u>
Net economic gain (+) or loss (-)	- Rs 20

The above are cases in which ill-advised protectionist measures create incentive for activities to be profitable financially, even though they represent net losses from an economic point of view. The following is an example of a project that is in fact worthwhile economically, but will not be undertaken because an unwise export tax has made the financially unviable.

World price (= \$20) at market exchange rate	= Rs. 200
Selling price net of 30% export tax (=financial return)	Rs. 140
Assumed financial cost	Rs. 180
Net financial return	- Rs. 40

Economic return	
World market price (\$20) at market exchange rate	Rs. 200
Augmented by foreign exchange premium	<u>+ 20</u>
	Rs. 220
Actual cost of domestic production	<u>Rs. 180</u>
Net economic gain (+) or loss (-)	+ Rs. 40

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 11:**

*ECONOMIC PRICES FOR NON-TRADABLE
GOODS AND SERVICES*

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ABSTRACT

Non-tradable items are those which are not traded internationally. They include items such as services where the demander and producer must be in the same location, and commodities which have low value relative to either their weight or volume. In such cases the transportation charges prevent producers from profitably exporting their goods. Typically, non-tradable goods include such items as electricity, water supply, all public services, hotel accommodation, real estate, construction, local transportation; goods with very high transportation costs such as gravel; and commodities produced to meet special customs or conditions of the country. The key element to be borne in mind when considering the tradable and non-tradable classification is where the price for the good (or service) in question is determined. If this determination takes place in the world market, the good should be considered tradable. If the setting of the price takes place by supply and demand in the local market, the good should be considered non-tradable. This chapter describes how the economic prices of non-tradable goods and services are estimated.

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CHAPTER 11

ECONOMIC PRICES FOR NON-TRADABLE GOODS AND SERVICES

11.1 Introduction

Non-tradable items are those which are not traded internationally. They include items such as services where the demander and producer must be in the same location, and commodities which have low value relative to either their weight or volume. In such cases the transportation charges prevent producers from profitably exporting their goods. Typically, non-tradable goods include such items as electricity, water supply, all public services, hotel accommodation, real estate, construction, local transportation; goods with very high transportation costs such as gravel; and commodities produced to meet special customs or conditions of the country.

The key element to be borne in mind when considering the tradable and non-tradable classification is where the price for the good (or service) in question is determined. If this determination takes place in the world market, the good should be considered tradable. If the setting of the price takes place by supply and demand in the local market, the good should be considered non-tradable.

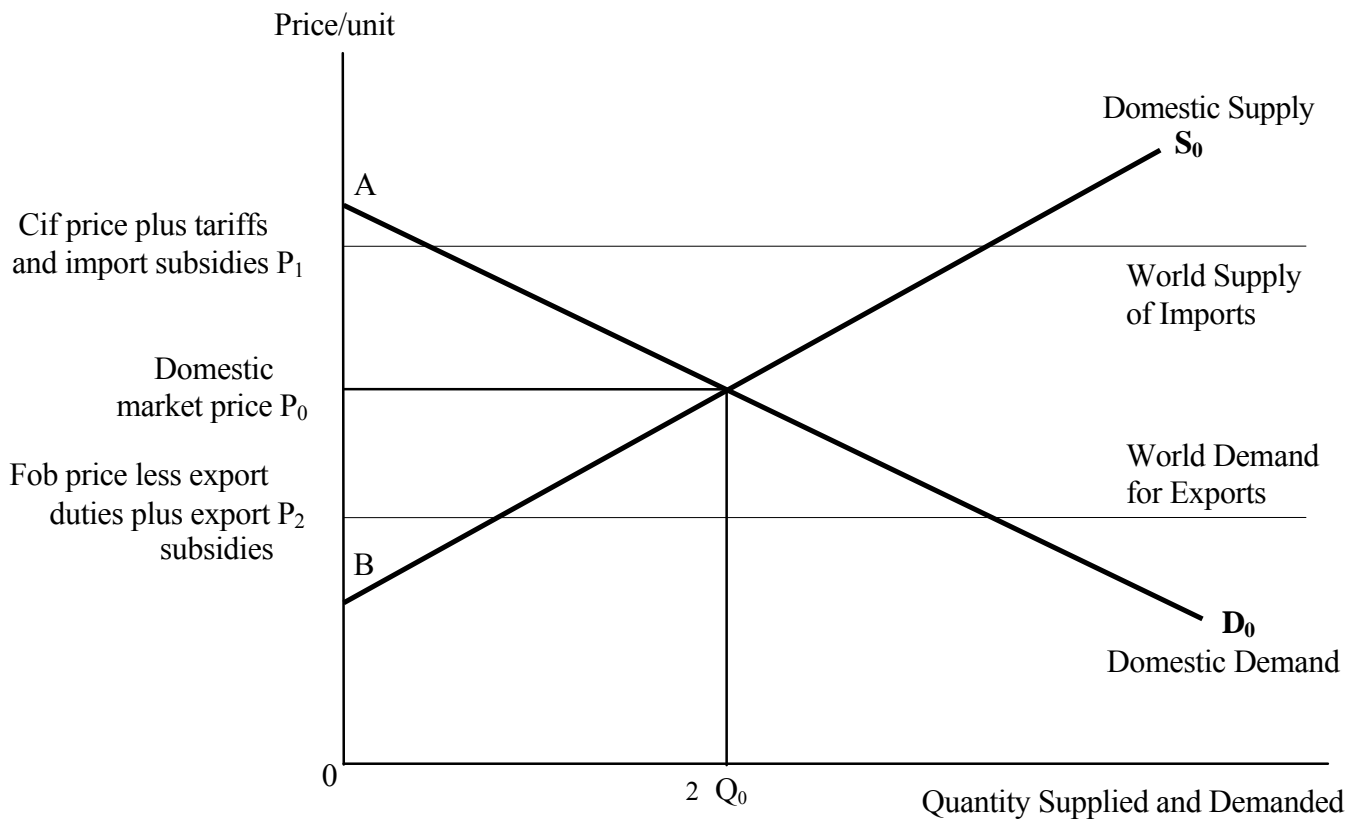
High rates of protection can easily cause a good which is internationally tradable to end up being properly classed as non-tradable. One example is rice in Japan, where imports until recently were explicitly forbidden, and where the internal price typically has been more than double the international price. Another is grocery items from advanced countries, which often sell in developing country markets for significant multiples of their fob price. Such high prices, whether caused by tariffs or by the low-volume, high markup characteristics of the imported good, lead to situations in which “similar” locally produced items have their prices determined by supply and demand in the local market,

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well under the “umbrella” price of the imported counterpart but still not being exported. When the price of locally produced merchandise is well below the “corresponding” local price of imported items, it is quite appropriate to treat local production as non-tradable, despite the anomalous price relationship.

If the cif price adjusted to include tariffs, taxes and import subsidies is greater than the market price and no imports of the good are present in the country, then it is clearly a non-tradable good from the point of view of that country or region of the country. Imports cannot compete with domestic production, at least with the existing level of tariff protection. Alternatively, if the fob price, less export duties but inclusive of any export subsidies, is less than the domestic market price of the item and no exports of the commodity are taking place, then again it is non-tradable. The standard relationships among the adjusted cif, adjusted fob and the market prices are illustrated in Figure 11.1 for the case of limestone.

Figure 11.1 World Prices, Domestic Price and Non-tradable Goods
-- The Case of Limestone --



As the cif price, plus tariffs less import subsidies (P_1) on limestone, is above the domestic market price (P_0), the domestic demanders will be unwilling to purchase imported limestone. Similarly, since the fob price, less export duties plus export subsidies (P_2), is less than the market price, domestic producers will be unwilling to sell abroad for a lower price than they can sell to domestic demanders.

11.1.1 Relationship between Tradable and Non-tradable Goods

The distinction between tradable and non-tradable goods is quite naturally right at the core of the field of international economics, and it carries over quite well to the field of cost-benefit analysis. In this area, however, a special case arises with respect to items that have no market prices, but must nevertheless be assigned a value for project evaluation purposes. Examples are the value of time saved as a result of a highway improvement, or the amenity values created by a public park or other cases where consumer surplus benefits are assigned, on top of actual market prices paid. Such items, not being actual outlays (or receipts) are not subject to shadow pricing. All actual cash outlays and receipts, however, should in principle, be classifiable as referring to one of the two grand categories, tradables and non-tradables.

To see how this distinction arises, and how it works, let us here simulate a certain path of evolution in our professional thinking about project evaluation. At the first step in this process, people focused on the actual imports that were made by a project, and the actual exports of its products. The cost of the imports reduced to the cost of acquiring the foreign exchange needed to buy them, and the value generated by the project's exports was the value of the foreign exchange that they produced. Even at this early stage there was a clear need to calculate an economic opportunity cost of foreign exchange, in order

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to accurately reflect the true economic costs (in local currency) of the project's imports and the corresponding true economic benefits of its exports.

This step, however, was only the beginning. For it soon became clear that there was also domestic production of many of a country's imported goods, and similarly, domestic use of many of its export products. In these cases, it really didn't matter whether the copper bought by a project was domestically produced or imported -- copper bought from a domestic source in the U.S. would simply lead to somebody else importing an equivalent amount, and wheat demanded by a Canadian project would leave that much less wheat to

be exported. Using T_i^d and T_i^s to represent the country's own demand and supply of i

importable good i , we have that imports of i (M_i) are equal to $T_i^d - T_i^s$. Similarly, using

T_j^d and T_j^s to represent the country's own demand and supply for exportable goods j ,

we see that exports of that good (X_j) are equal to $T_j^s - T_j^d$.

Now the country's total imports (M) can be represented as:

$$M = \sum_i M_i = \sum_i T_i^d - \sum_i T_i^s$$

Similarly, its total exports (X) can be represented as:

$$X = \sum_j X_j = \sum_j T_j^s - \sum_j T_j^d$$

The country's balance of trade is accordingly:

$$\begin{aligned} X - M &= \sum_j T_j^s - \sum_j T_j^d - (\sum_i T_i^d - \sum_i T_i^s), \\ &= (\sum_j T_j^s + \sum_i T_i^s) - (\sum_j T_j^d + \sum_i T_i^d) = T^s - T^d \end{aligned}$$

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Here T_s represents the sum of a country's total supplies of all tradables ($\sum_j T_j^s + \sum_i T_i^s$)

and T_d is the sum of its total demands for all tradables ($\sum_j T_j^d + \sum_i T_i^d$).

From here it follows that when there is equilibrium in a country's trade balance, there is also equilibrium between that country's total demand and supply for tradables. Similarly, a given deficit (M-X) in a country's trade will reflect an excess demand of equal size ($T_d - T_s$) for that country's total tradables.

The evolution of our ideas and procedures then moves a step further. It is certainly not enough just to look at the project's own actual imports and actual exports (step one). Nor is it enough to extend this just by considering the project's direct demand for and supply of tradable goods (step two). What is needed is a yet further extension to include the project's overall impact on the country's demand and supply of tradable goods (step three).

Although in principle a project may have more reverberations than we can conveniently capture the basic procedure that we suggest concentrates on the flows of "receipts" (sale of project output) and expenditures (project outlays for investment activities plus operating costs) over the course of a project's economic life.

The division of project outlays is represented in Table 11.1. When the project purchases tradables directly, the purchases are classified under item 1. This is true regardless of whether we bought goods that were actually imported, or goods that were domestically-produced items falling in the "importable" category, or goods that were domestically produced but falling in the "exportable" category. It is deemed that all three of these categories put pressure on the foreign exchange market either via direct demand (a) or via indirect demand (b), in which others do the importing, or via reduced export supply (c).

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When the project purchases non-tradables the story is a bit more complicated, because there are various ways in which this type of purchase can end up being reflected in incremental demand for tradables. We first look at that part of the project's non-tradables purchased (d) that ends up as increased output of the goods or services in question. This increased output will be reflected either in increased value added (d_1) or increased tradable inputs (d_2) or increased non-tradable inputs (d_3).

But the above does not tell the whole story, except when our project's full demand for non-tradables is met through increases in their supply. In the typical case, some fraction f_k^d of our project's demand will be met by squeezing out other demanders for the non-tradable goods and services in question. As we look for the consequences of this process, we must ask about the activities that are stimulated as some of the previous demanders of H_k reassign that demand to other activities. In particular we have to recognize that some of the relevant substitutes for H_k will themselves be tradable items, while others of the substitutes will, though non-tradable themselves, have tradable inputs. This is why, in Table 11.1 we have two items (e_1 and e_2) representing increases in tradables demand arising out of what happens when our project satisfies some of its extra demand for nontradables by displacing other demands for them.

Table 11.2 presents a numerical example, which may help readers see that the framework presented here is in the final analysis quite simple and straightforward. Here the direct outlays of the project are assumed to be divided 40 to direct purchase of tradables and 60 to the direct purchase of non-tradables. All of the amount spent on tradables stays there. The ground for this is that there is presumably no incremental domestic production of tradables arising out of our project's demand.

Things are different when it comes to our project's demand for non-tradables. Here there is every reason to believe that some increased production will be stimulated, but this will involve greater value added plus greater use of both tradable and non-tradable inputs.

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Thus, in the example of Table 11.2, we have 60 spent on construction of buildings by the project, of which 28 represents a net increase in construction and 32 represents a displacement of the demand of others; of the 28 of net increase, 6 are assumed to reflect increased demand for tradable inputs (d_2), while 22 reflect either increased value added in construction (14) or increased use of non-tradable inputs (8).

We now turn to the items representing project demand met through displacing other construction. What we are looking for here is not what resources were used to satisfy the demand before it was displaced. These resources are assumed now to be satisfying our project's demand. What we really want to learn about is what resources will be used in other places to satisfy the demand of others, which our project has managed to displace.

In item e it is assumed that part of this displaced demand (7) moves directly to the purchase of tradable substitutes. The remaining 25 is assumed to be shifted to non-tradables substitutes. But here it contains three components: tradable inputs (materials) taking 9, non-tradable inputs (purchased services) taking 6, and value added taking 10. In all, then, the correct division of our 100 of project outlays is 62 to tradables and 38 to non-tradables, almost the reverse of the initial 40 - 60 division of the direct expenditures.

In terms of the 60 of non-tradables purchased, its tradable content as a proportion of the total purchased is $T = 22/60 = 0.36$ and $NT = 38/60 = 0.64$.

Table 11.1
Classification of Project Outlays

	<u>Final Classification</u>	
	<u>Tradable</u> (T)	<u>Non-Tradable</u> (H)
1. Project Purchases of Tradables		
a. Actual Imports by Project (Mi)	X	
b. Importable Goods Produced in the Country (T _i ^s)	X	
c. Exportable Goods Produced in the Country (T _j ^s)	X	
2. Project Purchases of Non-Tradables (H _k ^p)		
d. Project Demand Met Through Increased Domestic Supply $(f_{kH}^{sp}) = \Delta H_k^s$		
d ₁ Value added in activity k = (v _k Δ H _k ^s)		X
d ₂ Tradable inputs into activity k = a _{tk} (Δ H _k ^s)	X	
d ₃ Non-tradable inputs into activity k = a _{hk} (Δ H _k ^s)		X
e. Project Demand for (H _k ^p) Met Through Displacing Other Demanders (f _{kH} ^{dp}) = (-Δ H _k ^d)		
e ₁ Demand displaced into tradable substitutes b _{tk} (-Δ H _k ^d)	X	
e ₂ Demand displaced into non-tradable substitutes $b_{hk} (-\Delta H_k^d)$		
value added e _{2v} = v _{hk} b _{hk} (-Δ H _k ^d)		X
tradable inputs e _{2t} = c _{tk} b _{hk} (-Δ H _k ^d)	X	
non-tradable e _{2h} = c _{hk} b _{hk} (-Δ H _k ^d)		X

Table 11.2
Classification of Project Outlays -- Numerical Example

	<u>Final Classification</u>	
	<u>Tradable</u> (T)	<u>Non-Tradable</u> (H)
1. Project Buys Tradable Goods (40)		
a. Actual Imports of Vehicles	20	
b. Petroleum (an Importable) from Local Sources	15	
c. Cotton (an Exportable) from Local Sources	5	
Sub-Total for Tradable Outlays	40	0
2. Project Constructs Buildings (Non-Tradables) (60)		
d. Project Demand met through net increase in construction (28)		
d ₁ . Value added in this increase in construction		14
d ₂ . Tradable inputs used in same (materials)	6	
d ₃ . Non-tradable inputs used in same (purchased services)		8
e. Project Demand met through displacing other construction (32)		
e ₁ . Demand displaced into tradable substitutes (machinery and equipment)	7	
e ₂ . Demand displaced into non-tradable substitutes (maintenance and repair)		
e _{2t} (materials)	9	
e _{2h} (purchased services)		6
e _{2v} (value added in maintenance & repair)		10
Sub-Total for Non-Tradable Outlays	22	38
Totals for Project	62	38

11.1.2 Economic Valuation of Non-Tradables

The estimation of the economic costs or benefits for tradable goods is simplified by the assumption that world prices of these goods and services can be taken as given. Unfortunately, the analysis is more complicated for non-tradable goods. It is similar, however, to the tradable case when supplies of the non-tradable goods in question are highly elastic. In such a case when more of a non-tradable is purchased by a project any tax paid on the input's purchase is included in the project's financial cost. Such taxes are excluded from the costs when estimating the economic cost of the input since the tax is not a true economic cost.

When a non-tradable good or service is produced purely by non-tradable inputs, the premium for expenditures on non-tradable goods and services, NTP, (calculated from the estimate of the shadow price of non-tradable outlays, SPNTO) should be added to the net of tax financial cost of the item purchased. The estimated value of NTP captures the value of the externalities lost when funds to finance the project's costs are raised from the capital market and the proceeds are used to buy non-tradable goods. The converse is also true. The value of NTP also measures the value of the externalities gained per dollar of output produced when the project sells a non-tradable output.

If our project produces or demands a standard non-tradable good with an upward-sloping supply curve and downward-sloping demand curve, their economic values are determined by the demand and supply of the good as well as the impact of the act on the rest of the economy. These cases are discussed in detail in the following sections.

Section 11.2 describes how the economic value of non-tradable outputs can be measured in the case of infinite supply elasticity. Section 11.3 considers the case of a non-tradable good in the standard supply and demand framework. Section 11.4 identifies some unique features of applying economic prices to the measurement of net economic benefits of a

project. Section 11.5 provides an example how the economic value of a non-tradable project input can be measured. Conclusions are made in the final section.

11.2 The Case of Infinite Supply Elasticity

The simplest case is for a project producing non-tradable outputs where its market supply function is infinitely elastic.¹ Electricity projects make an almost ideal case in point, for a number of reasons. First, the true intrinsic value of electricity to its demanders is quite hard to gauge. Second, electricity projects can take many forms -- run-of-the-stream hydro projects, daily reservoirs, seasonal dams, inter-annual storage dams, plus many others. To some, it seems almost hopeless to try to measure the benefits of each such project (heterogeneous even within any one of the listed types). Such fears are calmed, however, once it is realized that the true measure of the benefits of almost any type of electricity project is the alternative cost of generating a similar flow of energy by some more “standard” means. Standard alternatives exist, and they are in highly elastic supply. They consist of thermal generators of different types, which can closely approximate the type of energy flow that is likely to come from any given “idiosyncratic” project (with its own pattern of costs). The use of data in different types of thermal generating facilities enables us to give an alternative cost (= economic price) of energy of any given description (base load, peaking capacity, etc.). We can then calculate the economic cost of approximately replicating the energy output of any given new project. When the project is undertaken, its benefit is measured by the alternative cost of generating an equivalent flow of energy by “standard” thermal means. Such costs would be largely for tradable inputs -- the generators themselves, the fuel that would be used, etc. Consequently their foreign exchange costs will have to be inflated to take into account the existence of a foreign exchange premium. Additionally, non-tradable outlays would have to be adjusted to reflect the shadow price applying to them.

¹ For the supply of the output to be in perfectly elastic supply, it will also require all the inputs used in producing the output to also be in perfectly elastic supply. The infinite elasticity assumption is a good approximation of the economic value of a non-tradable good, especially in the long run, which is most relevant for the present analysis.

The end result of such an exercise would be the economic opportunity cost of providing the same energy of our project, but by standard thermal means. Our new plant, which is producing output x , would be worthwhile if its cost, appropriately adjusted to reflect economic rather than financial considerations, were less than (or at most equal to) those of its standard thermal alternative.

In this situation the value assigned to the electricity generated by our new plant is the value of the resources saved by not having to generate the electricity by alternative means. In the terminology of the three basic postulates of applied welfare economics² this economic value, P_x^e is equal to the supply price of the alternative electricity service of P_x^s . In some situations the market price, P_x , of this alternative generation technology may not reflect its true economic price. For example, this economic price would exclude any taxes that might exist on the fuel used by the alternative source of supply. These taxes might include such items as tariffs, excise and value added taxes on tradable goods, and value added taxes and excise taxes on non-tradable goods and services. Such taxes on inputs are not a resource saving or cost, but are transfers to the government. This adjustment is equal to $\sum_i a_{ix0} P_{im} d_i$ where a_{ix0} is the input-output coefficient of the input, i , used to produce a unit of x , while P_i is the price of a specific input i , and d_i is the tax wedge associated with the use of input i in the production of x . In this case the economic price of electricity is,

$$P_x^e = P_x^s - \sum_i a_{ix0} P_{im} d_i \quad (11.1)$$

Note that d_i expresses the tax or subsidy wedge as a fraction of the market price, P_i . Suppose the inputs used in the production of electricity by the other electricity suppliers

² Arnold C. Harberger, "Three Basic Postulates for Applied Welfare Economics," *Journal of Economic Literature*, IX, No. 3, (September, 1971).

are made up of tradable inputs equal to a proportion (T_x) of the total costs of production, and non-tradable inputs equal to a proportion (NT_x) of total costs. In deriving the economic value of a unit of electricity produced by our project a final adjustment must be made for the foreign exchange premium on the tradable resources released (FEP), and the value of the premium on non-tradable outlays (NTP) released by the alternative suppliers. In the case of thermal electricity supply we would expect T_x to be close to 1 and NT_x to be quite small. Of course, $T_x + NT_x = 1$, by definition.

This adjustment is an additional benefit that arises as tradable and non-tradable resources that are now made available to the economy as a consequence of our new plant's increase in supply. It measures the value of the generalized economic externalities enjoyed by the economy when resources are released as a consequence of our project. The opposite situation would exist if our project were demanding additional electricity that would be entirely supplied by these alternative generation facilities. Now the generalized externality would be counted as an additional economic cost of the input purchased. To summarize, in this special case of an infinitely elastic supply of alternative production, the economic value of a unit of good x being produced by our project is equal to:

$$p_x^e = p_x^m - \sum_i a_{ix0} P_{im} d_i + [p_x^m \times T_x \times \text{FEP}] + [P_x^m \times NT_x \times \text{NTP}] \quad (11.2)$$

11.3 A Non-Tradable Good in the Standard Supply-and-Demand Framework

Many markets for non-tradable goods (whether they be items that are produced by a project or goods and services that are purchased to build or operate a project) are characterized by upward sloping supply curves. In this section we first want to consider the steps in the economic evaluation of an output of a project that changes the price of the good or service. Following that we will consider how this mechanism can be used to value the economic cost of non-tradable inputs purchased by a project.

11.3.1 Economic Value of a Non-Tradable Output of a Project

For some non-tradable goods, the increase in output of a new project will lower the price of the good and hence will cause some displacement of alternative sources of supply. At the same time the lower price will create some incremental demand. This is a natural outcome of the standard supply-and-demand framework with upward-rising supply and downward-sloping demand curves.³ In this case some fraction of output of the new project will be reflected in a movement backward along the supply curve of the other sources of supply of the same goods, plus a movement forward along the total market demand curve for the good in question. The fractions applying to supply and demand (W^s and W^d) can be calculated using the price elasticity of supply (ϵ^s) and demand (η^d) for the goods⁴ as: $W^s = \epsilon^s / (\epsilon^s - \eta^d)$ and $W^d = -\eta^d / (\epsilon^s - \eta^d)$.

The economic prices associated with the changes in supply and demand as a result of a project are measured using the principles of applied welfare economics. Let P_x be the supply price per unit produced by those other than the project and P_x^d be the demand price per unit by domestic demanders of the good in question (project output plus other supply). The economic price (P_x^e) per unit of a non-tradable good x produced by a project can be measured by a weighted average of its supply price (P_x^s) and the demand price (P_x^d). The weights reflect the responsiveness of existing suppliers and demanders to changes in the price of the non-tradable good. That is:

$$P_x^e = W_x^s P_x^s + W_x^d P_x^d \quad (11.3)$$

where $W_x^s + W_x^d = 1$.

³ Some of the concepts for measuring economic welfare changes are elaborated further in Appendix 11A. ⁴ The relevant elasticities are those would characterize the markets in reaction on average over the life of the project.

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Let us now introduce distortions in the output market for the item. Suppose there is a production subsidy, k_x , expressed as a proportion of the net of subsidy price.⁵ In our terminology the marginal costs of production is defined as the good's supply price, sP_x . In addition, there is a tax levied at the rate of t_x on the market price P_x . This is the price that the supplier receives excluding any taxes that might have been paid by final consumer. The supply and the demand prices are thus, $P_x = P_m (1 + k_x)$ and $P_x^d = P_m \cdot (1 + t_x)$. Equation (11.3) can then be expressed as follows:

$$P_x^e = P_m (1 + W_x^s k_x + W_x^d t_x) \quad (11.4)$$

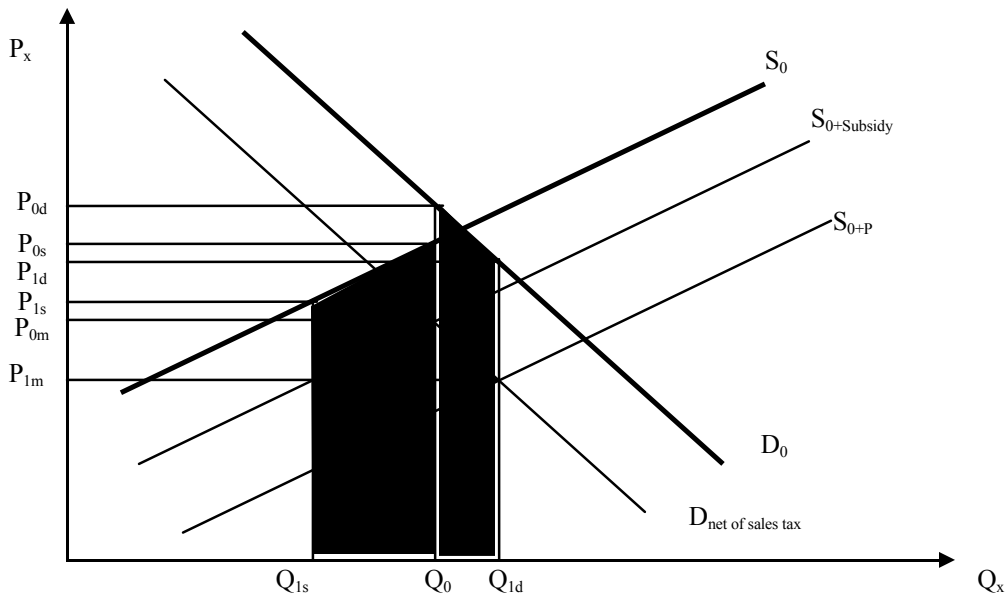
The conversion factor, obtained by dividing the economic value per unit of output equation (11.4) by its financial price exclusive of tax and subsidy, is equal to one plus a weighted average of the distortions in the product in the market, i.e. $P_x / P_m = (1 + W_x^s k_x + W_x^d t_x)$. However, if the financial price is inclusive of tax, the conversion factor will be equal to $P_x^e / [P_m (1 + t_x)]$. This may seem to be similar to the tradable case, but our problem is more complicated due to the impact that the project's output has on other distorted markets and the reallocation of resources in the economy.

In a standard supply-and-demand framework with upward-rising supply and downward-sloping demand curves, the economic price (P_x) of a non-tradable good x , can be estimated in a partial equilibrium analysis as a weighted average of the supply price (sP_x) and the demand price (P_x^d) as expressed in equation (11.4). The supply price of the product is measured by what producers actually receive (i.e. gross of any subsidy and net of any tax). The demand price is measured by what demanders actually pay (gross of tax). Suppose the good x is a telephone service produced by mobile telephones. The supply that the mobile telephone project displaces is likely to be communication services produced by the existing land-line telephones. The existing supply from all sources is

⁵ If instead, and perhaps more realistic, the subsidy could be provided as a proportion, K'_x , of the total resource costs, then $P_x (1 - k'_x) = P_m$, hence $P_x^s = P_m / (1 - k'_x)$.

assumed to receive a direct subsidy from the government equal to a fraction (k_x) of all their financial costs. Including the items discussed so far, the economic value of good x is shown by the shaded areas of Figure 11.2.

**Figure 11.2: Economic Costs of a Project:
-- When a production subsidy is present --**



On the demand side of equation (11.4), the amount of income spent on the incremental increase in the quantity of x demanded, measured by $W_x P_x^d$, will no longer be spent on other goods and services in the economy. In general, we would expect that some taxes would have been paid on these goods and services no longer being purchased. This effect should be captured by adding an economic cost (reducing the benefit) as the taxes associated with purchases of those goods and services are now forgone. Since we don't know precisely where those goods and services would be forgone, an average indirect tax distortion rate (d^*) on these items is assigned. Hence, the offsetting loss in taxes due to the diversion of demand toward good x will be $W_x P_x^m d^*$. The second term on the right hand side of equation (11.4) now becomes $W_x P_x^m (1 + t_x - d^*)$.

$$W_x P_x^m (1 + t_x - d^*)$$

If we did know that the additional quantity demanded of our non-tradable good was being drawn from a specific substitute good or service, y , then we would want to subtract the tax t_y lost due to the reduction in the purchase of this good from that of the additional tax paid of t_x . In this case the second term on the right hand side of equation (11.4) becomes

$$W_x^d P_x^m (1 + t_x - t_y).$$

Adjustments must also be made to the supply price of producing the good x . However, due to different adjustments required for different types of intermediate inputs used to produce the good x , we will deal with them in the following subsections.

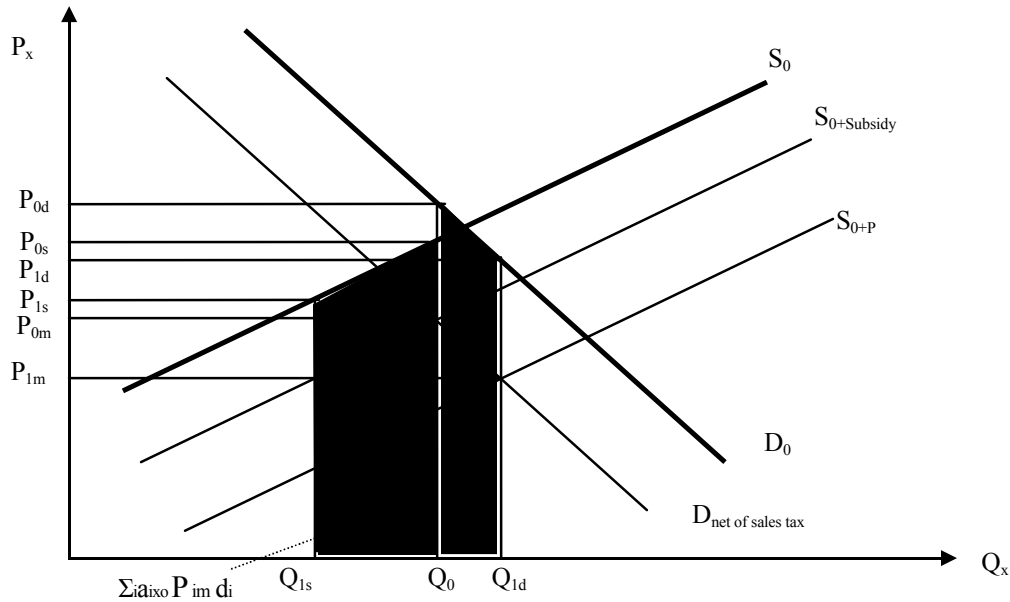
A. Intermediate Inputs with Infinite Supply Elasticity

Two further adjustments need to be made to the market price of the supply price of this good x in order to derive the value of the resources released by the non-project suppliers of the project output x . First, the supply price in equation (11.4), $[P_x^m (1+k_x)]$, does not take into consideration any tax distortions (d_i) levied on the intermediate inputs used to produce the existing supply of x that is being partially replaced by our project. These inputs will now go elsewhere in the economy to produce other goods and services. The value, however, of these resources saved should not include the taxes that will no longer be paid by the non-project suppliers. The composition of these intermediate inputs may differ depending upon whether the replaced supply of x was using an identical technology. Often the technology will be different than that used by our project.

Certainly the inputs released do not need to be of the same composition as those used by our project (i.e., $\sum_i a_{ix} P_{im}$). Suppose they are $\sum_i a_{ix0} P_{im}$. In the case where there are many such intermediate inputs, the adjustment made to the supply side of the economic price of

good x of equation (11.4) is $W_x [\sum_i a_{ix0} P_{im} d_i]$. This adjustment⁶ is shown in the lower part of the shaded area as $\sum_i a_{ix0} P_{im} d_i$ in Figure 11.3.

**Figure 11.3: Economic Benefits of a Project:
-- When a production subsidy is present --**



The second adjustment that has not been accounted for is the foreign exchange premium and the premium for non-tradable outlays associated with tradable and non-tradable components, respectively, of the non-tradable good. The sources of these premia are due to the fact that with the reduction in the production of the non-tradable suppliers of this good the resources released will reduce the demand for tradable inputs, and hence there is a saving of the foreign exchange premium associated with this component the resources saved. The same sort of externality arises when the non-tradable inputs released by the nontradable sources of the supply of the good. In this case it is the externality measured by the premium associated with our estimated value of SPNTO.

⁶ The value of this tax adjustment, $W_x \sum_i a_{ix0} P_{im} d_i$ is exactly correct only if the tax and subsidy distortions are on tradable inputs or on non-tradable inputs that are in perfectly elastic supply. This issue will be taken up again later in the chapter.

It is likely that when the final equilibrium is re-established after the project is implemented, the ultimate uses of tradable and non-tradable components of intermediate inputs would not be the same as the initial purchases of the intermediate inputs employed to produce the non-tradable good x . However, it is difficult to foresee the final usages of tradable and non-tradable components of intermediate inputs. For all intents and purposes, we assume the composition of tradable and non-tradable components of intermediate inputs remains unchanged. We would then adjust the economic value of the non-tradable good produced by increasing the cost of the tradable component of the non-tradable intermediate inputs required to produce the good x by the foreign exchange premium (FEP) and the cost of the non-tradable component of the non-tradable intermediate inputs by the premium of non-tradable outlays (NTP). That is,

$$+ (P_x^m \times T_x \times \text{FEP}) + (P_x^m \times NT_x \times \text{NTP}) \quad (11.5)$$

After taking into account all the repercussions as a result of producing the non-tradable good x in the economy, the economic price of the non-tradable good x can be measured as:

$$P_x^e = W_x^s P_x^m (1+k_x) + W_x^d P_x^m (1+t_x - d^*) - \sum_{i \in I_{xO}} a_{ix} P_{im} d_i + (P_x^m \times T_x \times \text{FEP}) + (P_x^m \times NT_x \times \text{NTP}) \quad (11.6)$$

Since the financial receipts of the non-tradable good x are $P_x (1+t_x)$, the conversion factor of this product will be:

$$CF_x = P_x^e / P_x (1+t_x). \quad (11.7)$$

B. Intermediate Inputs with Finite Supply Elasticity

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To this point we have been assuming that the only distorted inputs being used in the production of good x by its non-project suppliers were either internationally traded or if non-tradable they were in perfectly elastic supply. For those intermediate inputs that are neither internationally traded nor in perfectly elastic supply, a different adjustment is required to eliminate the value of the input distortion from the value of the resources released. Now the price of the input will be lower as the demand for the input is decreased. As a consequence, the demand and supply of the input j will both be affected and our objective here is to measure any distortions associated with the supply and demand sides of the non-tradable intermediate inputs j caused by the additional supply of the project's non-traded good x .

As our project produces more good x , the other producers of x will reduce their supply and hence their purchases of input j . The financial cost of the input j will be $P_j (1+d_j)$. Following the standard supply-and-demand framework with upward-rising supply and downward-sloping demand curves, because their price of j is now allowed to change the effect of this will be a cutback in the supply of j . The economic cost of the input j due to its supply response will be measured by the response of the input supply W_{js} times the price of the input P_j^m or $W_j^s (a_{jxo} P_j^m)$ where a_{jxo} is the input-output coefficient of the input, j , used to produce a unit of x . In the case there is a subsidy on the production of j , the economic cost will be measured by $W_j^s [a_{jxo} P_j^m (1 + k_j)]$ where k_j stands for the subsidy rate.

At the same time due to the drop in the price more of the input j will be demanded by other users of the input. We therefore want to estimate the economic value of the input j in the demand response as $W_j^d [a_{jxo} P_j^m (1 + t_j)]$. At the same time there will be an offsetting adjustment due to the diversion of j to other demanders. If these new purchasers of j pay the same tax t_j , there will be no net distortion to be deducted due to the diversion of the demand for j . However, it might be more appropriate to assume the average rate of distortion of d^* is paid by the new demanders of this input since we do not

know precisely where those inputs would be finally used. With this adjustment, the net economic value of the input j in the demand response should be measured by

$$W_j^d [a_{jxo} P_j^m (1 + t_j - d^*)].$$

From the above discussion, one can summarize that when the non-tradable input j with a finite supply elasticity is used to produce a non-traded good x , the adjustment to the supply side for the distortions on input j can be measured by the excess of the financial cost of the input j over and above its corresponding economic cost. That is,

$$- W_x^s \{ a_{jxo} [P_j^m (1 + t_j) - [W_j^s P_j^m (1 + k_j) + W_j^d P_j^m (1 + t_j - d^*)]] \} \quad (11.8)$$

Simplifying equation (11.8) by substituting $P_j (1 + t_j)$ with $P_j^m (W_j^s + W_j^d)(1 + t_j)$, the total distortion of tax and subsidy on non-tradable input j will become:

$$- W_x^s \{ a_{jxo} [W_j^s P_j^m (t_j - k_j) + W_j^d P_j^m d^*] \} \quad (11.9)$$

Both t_j and d^* are positive, their effect will be to reduce the economic cost of the final non-tradable good x while k_j is a subsidy on non-tradable supply of input j which is negative and will thus increase the economic cost of the final non-tradable good x .

We can use the symbol d_j to stand for $t_j - k_j$, which is equivalent to the distortions (d_i) associated with the tradable intermediate input i . Thus, equation (11.9) can be written as:

$$- W_x^s \{ a_{jxo} [W_j^s P_j^m d_j + W_j^d P_j^m d^*] \} \quad (11.10)$$

That being said, in a more generalized form one would assume that the production of good x by our project leads to the release of some intermediate inputs i_s by the non-project producers of which are in perfectly supply elasticity, along with the release of other intermediate inputs j_s with finite supply elasticities. After making all the above

adjustments including the distortions in the markets for intermediate inputs i and j , the measurement of P_x^e for equation (11.6) will be modified to become,

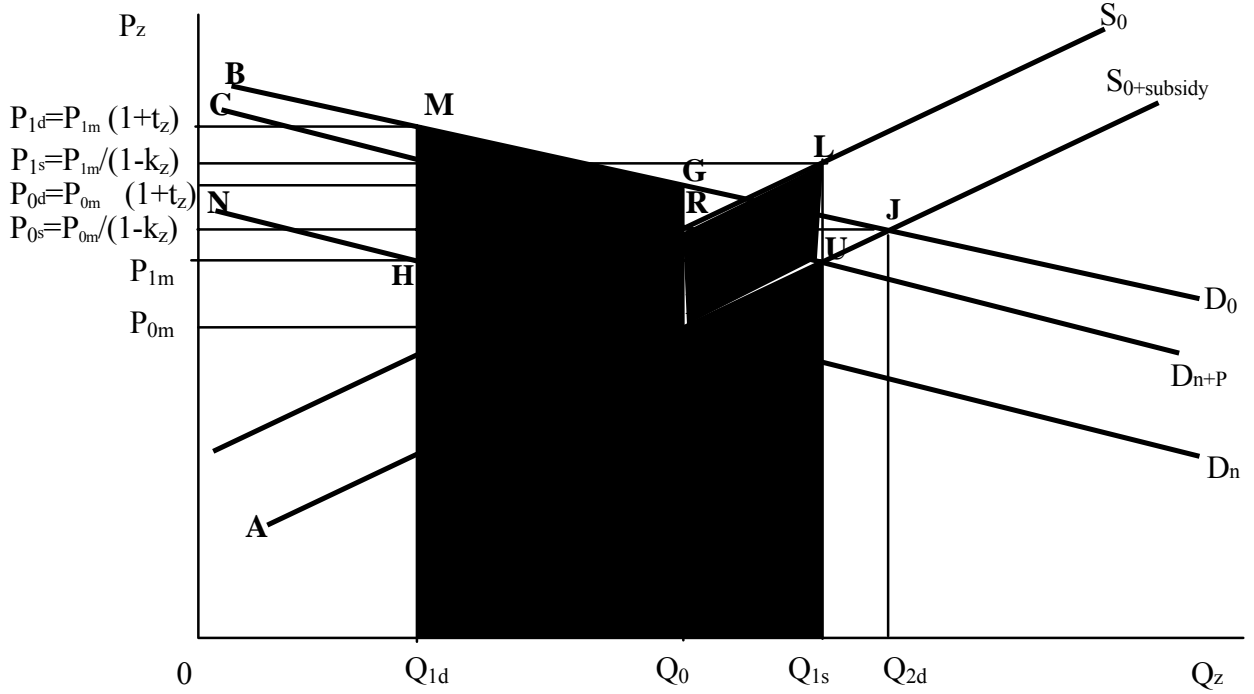
$$\begin{aligned}
 P_x^e = & W_x^s P_x^m (1+k_x) + W_x^d P_x^m (1+t_x-d^*) \\
 & - W_x^s [\sum_i a_{ix0} P_{im} d_i + \sum_j a_{jx0} (W_j^s P_j^m d_j + W_j^d P_j^m d_j^*)] \\
 & + (P_x^m \times T_x \times FEP) + (P_x^m \times NT_x \times NTP)
 \end{aligned} \tag{11.11}$$

The input-output coefficients in equation (11.11) relate to the factors and factor mix used by the non-project producers of x whose markets are being affected by our project.

11.3.2 Economic Value of a Non-Tradable Input Purchased by a Project

Figure 11.4 illustrates a situation of the market for an input z that is used to produce the good x . This input receives a direct subsidy equal to k_z of its production cost and when it is sold, this input is subject to a tax of t_z . When our project demands more of this input, its market demand curve will be shifted from ND_n to CD_{n+p} . This will stimulate additional supply of $(Q_{1s} - Q_0)$ and will cause the previous consumers of z to reduce their purchases by $(Q_0 - Q_{1d})$.

Figure 11.4: Economic Costs of a Project:
 -- When a production subsidy and a sales tax are present --



The first step in the estimation of the unit economic cost (eP_z) of this non-tradable input z that is purchased by our project is to consider cost from the value of the additional resources used by producers to supply more of z and the value placed on the demand by others that has been given up because the price of z has been raised. These two costs are measured by a weighted average of its supply price (sP_z) and the demand price (dP_z), respectively. The weights reflect the responsiveness of existing suppliers and demanders to changes in the price of the non-tradable input. That is:

$$P_z^e = W_z^s P_z^s + W_z^d P_z^d \tag{11.12}$$

where $W_z^s + W_z^d = 1$.

If we account for the market distortions explicitly then ${}^sP_z = P_m(1 + k_z)$ and

$P_z^d = P_z^m (1 + t_z)$, hence equation (11.12) can be written as:

$$P_z^e = W_z^s P_z^m (1 + k_z) + W_z^d P_z^m (1 + t_z) \quad (11.13)$$

The adjustments to account for the distortions on the prices of the additional inputs used to supply z or on the price of z when it was being previously purchased elsewhere are of the same form as in the case of an output x in equation (11.11). Similarly, the adjustments are made for the generalized distortions of the foreign exchange premium, when there is an impact on the demand or supply of tradable goods, and for the premium on non-tradable goods. That is, the term $(P_z \times T_z \times FEP)$ measures the additional cost associated with the additional tradable inputs that are now demanded because our project demands for the input z . Likewise, the term $(P_z \times NT_z \times NTP)$ measures the additional cost arising from the increased use of non-tradable inputs as a consequence of our project's purchase of this non-tradable input. The final expression for estimation of the economic price of input z in its generalized form is identical in form as in the estimation of the economic price of an output. It is shown as follows:

$$P_z^e = W_z^s P_z^m (1 + k_z) + W_z^d P_z^m (1 + t_z - d^*) - \left[\sum_i a_{izo} P_{im} d_i + \sum_j a_{jzo} (P_j^s P_j^m d_j + P_j^d P_j^m d_j^*) \right] (P_z^m \times T_z \times FEP) + (P_z^m \times NT_z \times NTP) \quad (11.14)$$

It is important to note that exactly the same structure and terms are present in equation (11.14) as in equation (11.11). It does not matter if a particular good is an input being purchased or an output being produced, its economic value is the same.

11.4 Application of Economic Prices to Estimate the Economic Net Benefits of a Project

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Where the nature of the market distortions are taxes and subsidies that are expressed as a proportion of a price, the natural way to introduce this conversion of financial values into economic values is through the use of commodity specific conversion factors. In such case, if the rates of distortion do not change then there is a fixed relationship between the real or nominal unit economic value of an item and its financial unit cost to the project. For example, consider a project input such as electricity or construction services that will be used over and over again in many projects. If the distortions in the output and input markets can all be expressed as a proportion of either P^m , P^d , or P^s then any one of these prices can be expressed as in terms of one of the other prices and the relevant distortions that make them not equal. Hence, it is also the case that we see from equation (11.11) that the economic price P^e of any good i can be expressed simply as a constant factor times the financial demand price of the same item. The constant factor will be a function of all the distortions and weights that determine the economic price of the item. This commodity specific conversion factor, CF_i , is the ratio of the economic price of i to its tax inclusive financial price, or its demand price,

$$CF_i = P^e_i / P^m_i (1 + t_i) \quad (11.15)$$

For inputs and outputs where these conditions hold, the economic benefits and costs can be estimated period by period by simply multiplying the financial line items of financial analysis from the total investment point of view by the corresponding commodity specific conversion factor for that line item. The result is the value of the economic benefit or the value of the cost item for that period. When all the line items of a financial cash flow analysis are converted into their economic values then it is a relatively simple procedure of subtracting the costs from the benefits to derive the periodic economic net benefits and the economic net present value of the project.

Of course when there are distortions such as rationing, quantitative restrictions, consumer surplus arising from new market entrants, then the economic value of the additional consumption will be divorced from the particular financial prices charged. The value of

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the output of a road, when no tolls are being charged is a classic example where the output of the road has to be evaluated based on the fundamental items that measure the consumers' willingness to pay and the economic value of the resources saved, and in this case these values are completely divorced from what the user of the road pays for the service.

The items where conversion factors can not be used are usually associated with the outputs of projects. Examples include the benefits from improving a road, the benefits from providing access to potable water supplies, and the benefits of improving the reliability of the electricity service. In all these cases the engineers and sector specialists will often have the professional training on how to measure the economic value of the output produced by the project.

A major hurdle to the widespread implementation of economic cost-benefit analysis is the dozens, and sometimes hundreds of inputs for a single project for which the sector specialist has little idea, or the time, to go about making an estimation of the economic prices of each of these commodities and services. The major advantage of expressing the relationship between the unit economic value and the unit financial value as a conversion factor is that for as long as the rates of the distortions do not change, then the same conversion factor can be used for the same good across many projects in the country. In addition, the conversion factor is not affected by the rate of inflation. Hence, it can be applied to either the nominal financial values of a particular item over time to obtain its nominal economic values through time, or it can be applied to the real values of the same item and the result will be the real economic value of the item over time.

Furthermore, the nature and magnitudes of the distortions that determine the size of the conversion factor for a particular good or service can be clearly written as a formula using the relationship shown in equations (11.11) and (11.14). Hence, when it is known that the rate of tax or subsidy has changed then the conversion factors for the items affected can be readily updated.

11.5 An Illustrative Example

Consider a project in South Africa using bricks as an input where there are distortions in the markets of bricks, and in the markets two inputs, clay and furnace oil, are used to produce brick.

Assume that the market for bricks is competitive, the market price is subject to a 14% general sales tax without any tax credit and brick producers receive a 15% subsidy (k_z) on their total production cost. In this case, the supply price is expressed as $P_z = P_z^m / (1 - k_z)$ because the subsidy is the fraction of the supply price. Without the project, the quantity demanded and supplied in the market is 7 million bricks per month at a market price (P_z) of R0.2 per brick. Now introduce a project that requires 300,000 bricks per month. Two of the inputs used in the production of bricks have distortions in their markets: (a) clay, a non-tradable good, has a 14% sales tax levied on its market price (P^{clay}) of R7 per ton,⁷ (b) furnace oil, an import good, has a subsidy (k_{oil}) of 20% on its cif price of US \$240 per ton. The input-output coefficient for furnace oil (a_{oilz}) is 180 kilograms of oil per 1000 bricks and that of clay (a_{clayz}) is 3.5 tons of clay per 1000 bricks. The market exchange rate is R9.85 per US dollar.

The weighted average excise and other indirect tax rate on tradable and non-tradable goods and services in the economy (d^*) is 9%.

The economic cost per brick can be estimated using equation (11.14). Data requirements for the estimation of the economic price (P_z) of a brick used by the project as an input are described below.

⁷ It is assumed that the change in the market price of clay on account of the project's demand is relatively small, hence justifying the use of without-the-project prices, rather than an average of the prices with and without the project.

Brick*Step 1: Price Estimation*

Since $P_z^m = R0.2$, thus $P_z^s = P_z^m / (1 - k_z) = 0.2 / (0.85) = R0.2353$,

$$\text{and } P_z^d = P_z^m \times (1 + t_z) = 0.2 \times (1.14) = R0.2280.$$

Step 2: Estimation of the Supply and Demand Weights (W_z) and (W_z^d)

For such a production activity, the expected supply response will be small in the short run as most brick making kilns are usually operating close to capacity. Although the supply response will be larger in the longer run, it will still not be as large as the demand response. In other words, a larger proportion of the bricks required by the project will be obtained at the expense of existing demanders who will divert to other things, rather than from new production. Hence, assigning a weight of 0.33 to the demand side (W_z) and a weight of 0.67 to the supply side (W_z^d) seems plausible.

Step 3: Tradable, Non-tradable Good Component in Brick Production

By examining the cost components used in the production of bricks, we are given that the tradable good component and non-tradable good component account for 60% and 40%, respectively, of the market price of bricks. The foreign exchange premium is equal to 6% and the premium on the purchase or sale of non-tradable goods and services is 1%.

Step 4: Product Distortions

The supply price on the newly stimulated supply of brick, as was calculated above, is equal to,

$$P_z^s = P_z^m / (1 - k_z) = 0.2 / (0.85) = R0.2353,$$

On the demand side, the tax on good t_z that other demanders will not be paying because they are now buying other goods is partially offset by the taxes they will now pay d^* .

Hence, the opportunity cost of the forgone consumption of others is equal to,

$$P_z^m [1 + (t_z - d^*)] = 0.2 (1 + 0.14 - 0.09) = R0.21.$$

Furnace Oil

Since furnace oil enjoys a subsidy, its financial market price is different from its economic price and so an adjustment for this input will have to be made when estimating the economic cost of bricks.

Step 1: Estimating the Market Price

$$\begin{aligned} P^{oil} &= \text{cif price} \times E^m \times (1 - s_{oil}) \\ &= 240 \times 9.85 \times (1 - 0.2) \\ &= R1,891 \text{ per ton} \end{aligned}$$

Step 2: The Economic Cost of Furnace Oil (p_{oil})

$$\begin{aligned} p_{oil} &= \text{cif price} \times E^m \\ &= 240 \times 9.85 \\ &= R2,364 \text{ per ton} \end{aligned}$$

The value of the subsidy per ton of furnace oil is estimated below.

The value of the subsidy = $p_{oil} - P^{oil}$

$$\begin{aligned} &= - \text{cif price} \times E^m \times s_{oil} \\ &= - 240 (9.85) (0.2) \\ &= - R472.8 \text{ per ton} \end{aligned}$$

Thus, the value of the distortion per brick is - R0.0851

$$(- a_{oilz} * R472.8 / 1,000 = - 0.18 * R0.4728).$$

Clay

As clay is subject to 14% of the sales tax, its demand price is different from its market price and an adjustment for this input is necessary when estimating the economic cost of bricks.

Step 1: Estimating the Demand and Supply Prices for Clay

$$\begin{aligned} \text{Since } P^{clay} &= R7 \text{ per ton, thus } P_{clay} = P^{clay} * (1 + t_{clay}) = 7 * (1 + 0.14) = R7.98 \text{ per ton} \\ \text{and } P_{clay} &= P^{clay} * (1 - k_{clay}) = 7 * (1 - 0) = R7 \text{ per ton} \end{aligned}$$

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Step 2: Estimation of the Supply and Demand Weights (W_{clay}^s and W_{clay}^d)

If clay is not in short supply, one can reasonably assert that the demand for clay derived from the project's demand for bricks will be mostly met from additional supply.

Accordingly, a demand weight (W_{clay}^d) of 0.33 and a supply weight (W_{clay}^s) of 0.67 are assigned.

Step 3: The Economic Cost of Clay (P_{mclay}^{clay})

Using clay as an input will lead to additional supply as well as displaced demand for some existing demand, the value of the distortion created after taking into account all the repercussions of the demand for clay in the economy can be estimated as:

$$\begin{aligned} P_{mclay}^{clay} &= \{ a_{clayk} [W_{clay}^s (d_{clay} - k_{clay}) + W_{clay}^d d^*] \} \\ &= 7 \{ 0.0035 [0.67 * (0.14 - 0) + 0.33 * 0.09] \} = \\ &= 0.0245 \text{ (.1235)} \\ &= 0.0030R/brick \end{aligned}$$

Taking into account the distortions in the product and input markets, the economic price per brick by substituting in equation (11.14) repeated below:

$$\begin{aligned} P_z^e &= \frac{W_z^s P_z^m}{(1 - k_z)} + W_z^d P_z^m (1 + t_z - d^*) \\ &\quad - W_z^s \left[\sum_j a_{jz} P_j^m d_j + W_j^d P_j^m d^* \right] \\ &\quad - P_z \left[\sum_i a_{iz} P_i^m d_i + \sum_j a_{jz} P_j^m d_j + \sum_k a_{kz} P_k^m d_k + \sum_l a_{lz} P_l^m d_l \right] \\ &= 0.67(0.2353) + 0.33(0.2100) - 0.67(-0.0851 + 0.0030) + 0.2 * 0.6 * 0.06 + 0.2 * 0.4 * 0.01 = \\ &= 0.1577 + 0.0693 + 0.0550 + 0.0080 \\ &= 0.2900R/brick \end{aligned}$$

To estimate the commodity-specific conversion factor for bricks used by the project, we divide the economic price by the financial demand price. Recall that the demand price is inclusive of sales tax. That is,

$$CF = 0.2900/0.228 = 1.27$$

The same methodology can be used to estimate the conversion factors for a series of non-tradable goods and services involved in projects. In the case of project supply or project demand for tradable goods, it often requires non-tradable services such as truck transportation services and handling charges in order to move the goods between the port and the project site. The financial costs for these services must be converted using the respective conversion factors to the economic costs in the economic appraisal.

As was mentioned in Chapter 10, for example, the irrigation project in Visayas of the Philippines is required to import pesticides to improve the farm's productivity. The project will also incur handling charges, dealers' margin, and transportation costs in order to move pesticides from the port to the farm. Thus, in addition to 4,239 pesos paid for the duty-paid value of the item, the project will also pay a total of 1,140 pesos for handling and port charges, 475 pesos for transportation costs from the port to the farm gate, as well as 200 pesos for dealers' services. Each of these non-tradable service costs presented in the financial cash flow statement must be converted to the economic costs in the economic resource flow statement using their corresponding conversion factors calculated as outlined in this chapter.

11.6 Conclusion

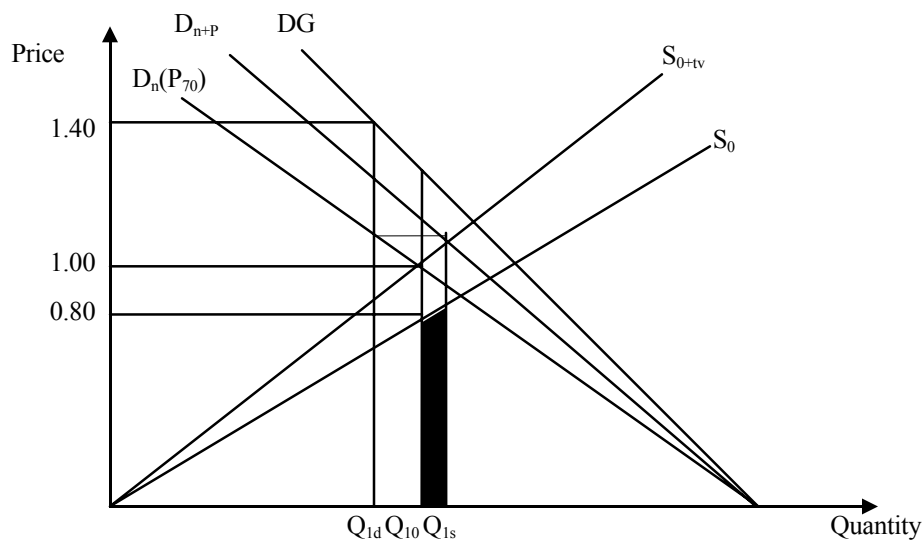
This chapter has described the analytical framework how the economic prices of nontradable goods and services can be estimated. Unlike the case of tradable goods, there will be no direct world price, but an equivalency to the world market can be derived. The analysis began with the case in which a project produces non-tradable outputs where its market supply function is perfectly elastic and then moved to the standard case with upward-rising supply and downward-sloping demand curves. The analysis takes into account all repercussions of the project in the economy by capturing all distortions in the direct product and indirect input markets.

Appendix 11A Choosing the Relevant Distortion

This appendix provides readers with the basic toolbox concerning very basic supply-and-demand relationships. We start with a commodity that is subject to both an excise tax and a value added tax. We assume that the posted market price is inclusive of VAT (as is the practice in most VAT countries), and that the excise tax is added to the market price, as an extra item on the buyer's bill. In short, in this presentation we assume that the VAT is institutionally paid by the supplier, where the excise tax is paid by the demander. The ultimate incidence of these taxes is another issue.

This yields the supply-and-demand picture shown in Figure 11A. In the Figure, the value added tax is 25 percent (on a base price of 0.80), while the excise tax is 40 percent on a base price of 1.00. When a new demand is introduced, say by our project, 70 percent of that demand is met by displacing other demand and 30 percent by generating new increments of supply. In this case, the economic opportunity cost of meeting new demand for this good will be $(0.7 \cdot 1.40) + (0.3 \cdot 0.80) = 1.22$.

Figure 11A



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$$Q_{1s} - Q_{1d} = 100 \text{ units}, Q_{1s} - Q_{10} = 30 \text{ units}, Q_{10} - Q_{1d} = 70 \text{ units}$$

One way to visualize this opportunity cost is that we do not know whether our project will or will not be required to pay tax on its purchases. Perhaps, as a government project, it will be exempt from the excise tax, or maybe even from both taxes. Perhaps as a private project producing for export, it will be exempt from both taxes. The point is that as we try to establish the economic opportunity cost of the product Q_1 , we do not know what taxes the buyer will be required to pay. We do know, however, that suppliers will incur a resource cost of 0.80 on the incremental supply, and that demanders will be forgoing units of Q_1 that the value at (or a bit above) 1.40 on 70 percent of the amounts that our project takes.

Thus we have unambiguously established that the economic opportunity cost of Q_1 is a weighted average of supply and demand prices.

Let us now consider another problem dealing with the same market. Our project is now in some quite different area. Its output is a non-tradable good or service, Q_7 , and as a consequence of the project the total demand for Q_7 increases. A likely scenario is that the price of good falls from P_{70} to P_{71} . Because good Q_7 is a substitute for Q_1 , when the quantity demanded of Q_7 increases, the demand declines for Q_1 .

Figure 11B

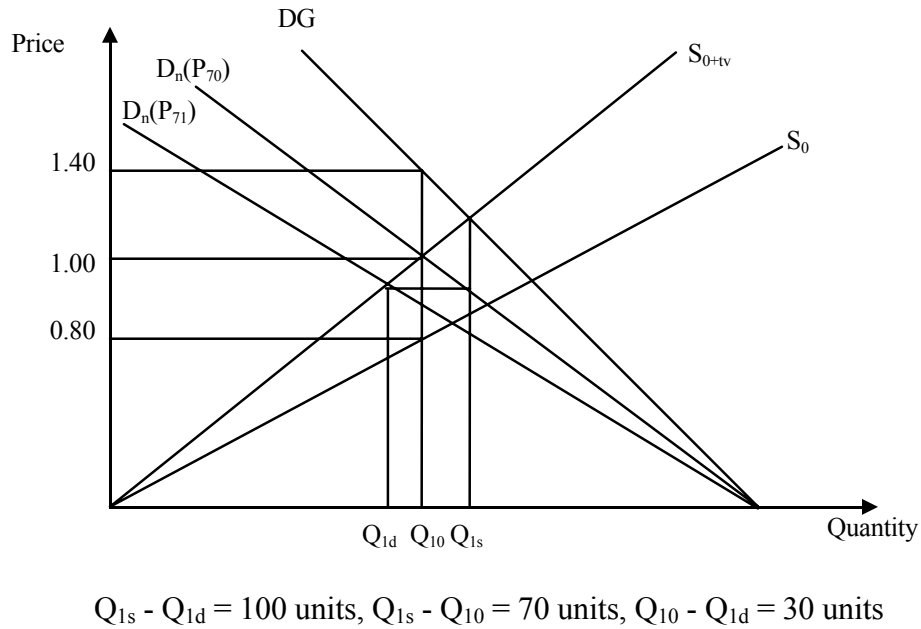


Figure 11B illustrates this case for an induced shift in demand (away from Q_1) and toward Q_7 , equal to 100 units. Note in Figure 11B, that we can still say (if we want to) that the economic opportunity cost of those 100 units of shifted demand is $(0.3 \cdot 0.80) + (0.7 \cdot 1.40) = 1.22$, as before.

But this is not a very good way to summarize what is going on. What actually happens is simply a reduction of the equilibrium quantity of Q_1 by 30 units. In the exercise of Figure 11B, certain demanders (call them the shifTERS) shift 100 units of demand away from Q_1 . In order to buy more of Q_7 , they induce a bunch of other demanders of Q_1 (call them the stayers) to augment their demand by 70 units. But that change of +70 units by the stayers is more than canceled by the -100 unit change produced by the shifTERS. The end result is a net reduction in demand for Q_1 of 30 units, which necessarily also equals the reduction in supply.

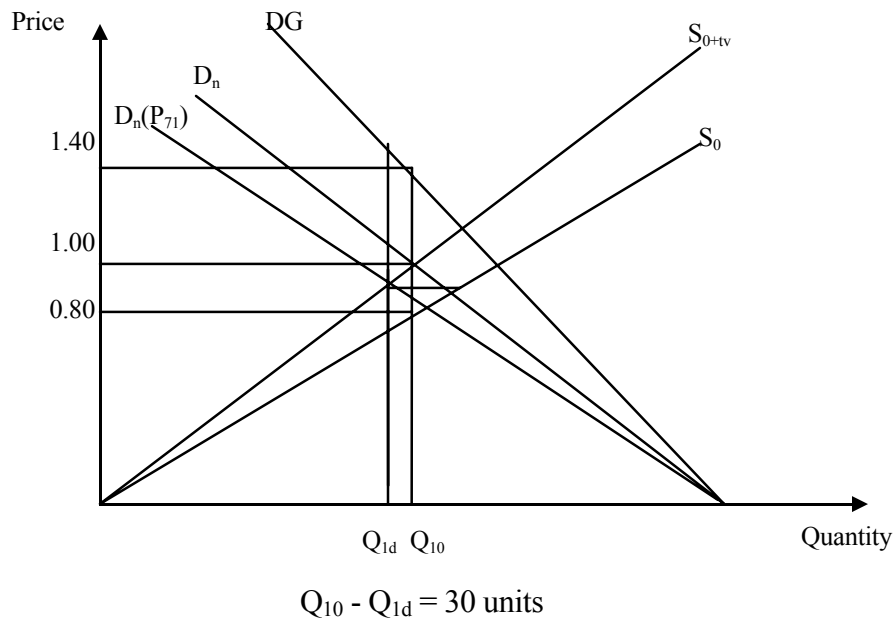
Figure 11C shows a better picture of what happens in the market for Q_1 , as a consequence of a project-induced increase in demand in the market for Q_7 (the project good). This

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Figure allows for the induced increase in demand of 70 (by the stayers) to be fully canceled by the project-generated reduction in demand for Q_1 of 100 (by the shifters). The net result is a reduction of -30 in the equilibrium quantity of Q_1 , to which a distortion of 0.60 (=1.40 - 0.80) applies. In this case the distortion effects are not split between a supply change in one direction and a demand change in the other, but are combined into a simple grand distortion (= demand price minus supply price), which applies to the net change in the equilibrium quantity of the good in question (here Q_1).

Note that this example is relevant for all kinds of external effects that take place outside the purview of the project we are analyzing. When we deal with “our” project’s demand, we want to separately consider the distortions applying to increased supply and decreased demand (or vice versa). But in cases where we are examining induced effects in other markets, those effects are necessarily shifts (up or down) of the equilibrium quantity of good Q_j , in whatever market that might be.

Figure 11C



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Our important corollary of this simple lesson, is that when we have an increase in demand of, say 400, for the project good Q_7 , of which 100 came by the shifters substituting away from good 1 and toward Q_7 as a consequence of our project. We do not want to assign our externality of $(1.22 - 1.00) \cdot (-100)$ of shifted demand for Q_1 . This would equal -22. Nor do we want to assign an externality of $(1.22 - 0.80) \cdot (-100)$, which would equal -42. The correct externality assignment is of $(1.40 - 0.80) \cdot (-30) = -18$.

It is a pity that this simple lesson is not widely understood, even among experienced project economists. It follows directly from the standard expression for measuring external effects $\sum_i D_i \Delta Q_i$, where D_i is the distortion affecting activity i and ΔQ_i is the amount by which the equilibrium quantity of Q_i changes, as a consequence of the event being analyzed (in this case “our” project in the market for Q_7).

Thus when we consider increases in demand for project output, even if all the increase in demand were to come from Q_1 that does not mean we should assign a Q_1 distortion to that full increase of 400 in demand for Q_7 . In this case we would assign the full Q_1 distortion of 0.60 per unit to a shift in equilibrium quantity of Q_1 , equal to -120 [$=0.3 \cdot (-400)$]. That is, the externality $D_i \Delta Q_i$ would equal $(0.60) \cdot (-120) = -72$.

In dealing with the Q_7 market, we would have project output of 1,000, of which 600 would be reflected in reduced supply by others and would be assigned a distortion equal to d^* (as those resources find their new equilibrium locations elsewhere). Then we would have 400 of increased output of Q_7 , to which the tax T_7 would apply (i.e., our project’s output would be valued at its demand price). And finally on the externality applying in the market for Q_1 we would have a Q_1 externality equal to $D_1 \Delta Q_1 = -72 (= -120 \cdot 0.60)$, plus an additional externality of $+120 \cdot d^*$, as the resources released from Q_1 are absorbed elsewhere in the economy.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 12:**

THE ECONOMIC OPPORTUNITY COST OF LABOR

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ABSTRACT

The concept of economic opportunity cost is derived from the recognition that when resources are used for one project, opportunities to use these resources are sacrificed elsewhere. Typically when workers are hired by a project, they are giving up one set of market and non-market activities for an alternative set. The economic opportunity cost of labor (EOCL) is the value to the economy of the set of activities given up by the workers including the non-market costs (or benefits) associated with the change in employment. When determining the EOCL, it is important to remember that labor is not a homogeneous input. It is perhaps the most diverse factor of production in any economy. In this chapter we will examine how the EOCL is estimated in an economy that contains markets for many different types of labor occupations, with variations by region, by quality of employment opportunities (e.g., pleasant, unpleasant, permanent, temporary, etc.) that affect the EOCL used by a project.

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CHAPTER 12

THE ECONOMIC OPPORTUNITY COST OF LABOR

12.1 Introduction

The concept of economic opportunity cost is derived from the recognition that when resources are used for one project, opportunities to use these resources are sacrificed elsewhere. Typically when workers are hired by a project, they are giving up one set of market and non-market activities for an alternative set. The economic opportunity cost of labor (EOCL) is the value to the economy of the set of activities given up by the workers including the non-market costs (or benefits) associated with the change in employment.¹

When determining the EOCL, it is important to remember that labor is not a homogeneous input. It is perhaps the most diverse factor of production in any economy. In this chapter we will examine how the EOCL is estimated in an economy that contains markets for many different types of labor occupations, with variations by region, by quality of employment opportunities (e.g., pleasant, unpleasant, permanent, temporary, etc.) that affect the EOCL used by a project. We focus primarily on the conditions and distortions in the labor market and do not at this point bring into the discussion the potential impacts which employment of domestic labor might have on the market for savings or foreign exchange.²

¹ Harberger, A.C., "The Social Opportunity Cost of Labor: Problems of Concept and Measurement as Seen from a Canadian Perspective", *Report for the Canadian Immigration and Employment Commission, Task Force on Labor Markets*, (Ottawa, 1980).

² In the evaluation of the economic opportunity cost of labor we do not take into account the potential impact on national savings of changes in the amount of income received by labor. This decision is based on three observations. First, most of the labor hired by our project would have been employed elsewhere in the absence of the project. Second, the overall level of national savings is fundamentally determined by macroeconomic and the public sector budgetary conditions. Third, the level of uncertainty surrounding the quantitative estimates of the size of the distortion attributed to savings, and the impact on national savings from labor receiving more or less income from a project, warrants considerable caution. If, however, a particular project is deemed to have a measurable impact on savings, and there is an externality associated with this impact, then the value of this externality should be included in the evaluation of the economic NPV of that project. In a similar manner, we do not take into consideration the indirect effects on distorted markets, such as foreign exchange, due to the movements of labor from other activities to the project. If the quantitative impact of the indirect effects that occur via the foreign exchange market or any other distorted market is known, the value of this externality should be included in the evaluation of the economic benefits and costs of the project.

A labor externality (LE_i) is created for any project, when the economic opportunity cost of labor ($EOCL_i$) differs from the wage rate (W_{p_i}) paid to the labor by the project. This externality can be expressed for a specific type of labor (i) as:

$$LE_i = W_{p_i} - EOCL_i \quad (12.1)$$

When LE_i is positive, then the financial cost of labor will be greater than its economic cost, and vice versa. As we will see from this analysis, the magnitude of this externality is a function of more variables than just the rate of unemployment in the relevant labor market for this class of workers. It will also depend on other distortions in the labor market such as taxes, unemployment insurance and protected labor market segments. We also find that it will be affected by the quality of the job created. The magnitude of this externality is one factor causing the economic performance of a project to diverge from its expected financial outcome.

12.2 Alternative Approaches to Estimating the Economic Opportunity Cost of Labor

In estimating the EOCL two alternative starting points for the analysis of this variable may be chosen: (i) value of marginal product of labor forgone, and (ii) supply price of labor. Note that calculating the EOCL using either method will theoretically produce the same result. These two approaches, however, have different data requirements, levels of computational complexity and, hence, different degrees of operational usefulness.

(i) Value of Marginal Product of Labor Forgone Approach

The value of marginal product of labor forgone for labor hired by a project is determined by starting with the gross-of-tax alternative wage (W_a) that the labor hired for that project would have earned in its absence. In most cases, there will be at any future point in time an estimated distribution of the labor activities in the presence of the project, and an alternative distribution in its absence. Normally, the differences between these two allocations will sum to zero, especially if leisure and involuntary unemployment are counted among the relevant activities.

This means that the net reductions in labor allocated to other activities must add up to the amount of employment provided by the project. If one works strictly with Forgone marginal product, the opportunity cost of labor for the project would simply be the weighted sum of the Forgone marginal products of labor of all different types sourced from the various activities.

This method is not well adapted to taking differences in the underlying working living and conditions that do not directly reduce output elsewhere in the economy.³ Historically, some economists have argued that the value of the marginal product of unskilled agricultural workers in developing countries was zero because it was believed that there was a large surplus of labor in the countryside. However, empirical studies of subsistence farmers have demonstrated that their labor does have a positive marginal value both in farming and in a variety of other productive activities. Using the assumption that the value of the marginal product Forgone is zero when hiring unemployed workers, this approach leads to an underestimation of the EOCL and the estimate does not reflect the true economic costs of the project using the labor.⁴

(ii) Supply Price of Labor Approach

An alternative method, based on the supply price of labor is more straightforward and easier to use under a wide variety of conditions.⁵ The starting point of this analysis is the market wage (the supply price) required to attract sufficient people of the required skill level to work on the project. The supply price of labor to a project is the minimum wage rate the project needs to pay to obtain sufficient supplies of labor with the appropriate skills. That wage will account for the worker's preferences regarding the location, working conditions or any other factors that affect the desirability of working for the project. For example, if a very high local market wage is required to attract skilled labor to a project where the living conditions are bad, then that wage already includes both the value of the forgone wage and the compensation for the economic costs inflicted by the relatively bad living conditions. Of course, the supply

³ Little, I.M.D. and Mirrlees, J.A., *Project Appraisal and Planning for Developing Countries*, London: Heinmann Educational Books, (1974).

⁴ For a summary of this debate see Marglin, S.A., *Value and Price in the Labour-Surplus Economy*, Oxford: Clarendon Press, (1979), pp. 10-23.

price should be adjusted further to account for other distortions, such as taxes, to arrive at the EOCL. But unlike the marginal product Forgone approach where one must measure both of these components separately, the local supply price directly captures in a combined package the wage and the non-wage costs of employing labor on the project.

In practical terms, the supply price of labor can be determined by asking the question - what is the minimum wage the project must pay to get an adequate number of applicants to work for this project with an acceptable turnover rate? This can often be done by informally surveying workers near the location of the project or using a more formal assessment of the prevailing wage in that activity. To test whether the wage rate being paid by a project is the minimum supply price one should compare the number of applications by qualified people with the number of positions available. If the number of acceptable applications per job available is very high, and the turnover rate for the project is abnormally low, then it is likely that the wage rate paid by the project is above the minimum supply price. However, if the ratio of qualified applicants to positions available is low, it indicates a fairly tight labor market and the turnover rate is high for the type of skill required; we can be quite sure that the project wage is close to the minimum supply price of labor.

Once the minimum supply price of labor has been determined, the EOCL is calculated by adjusting that value to account for relevant distortions (such as income taxes or subsidies). Care must be taken at this point to ensure that all of the market distortions which drive a wedge between the supply price and the economic opportunity cost of labor are properly accounted for when estimating the EOCL for the project. The evaluation of a number of these distortions is taken up in the following sections of this chapter.

To compare these two methods in calculating the EOCL, let us consider the example of unskilled farm workers who have decided to move from their alternative jobs of cutting sugar cane (c) to work on a new project in a more pleasant place (o) harvesting oranges.

⁵ Harberger, A.C., "On Measuring the Social Opportunity Cost of Labor", *International Labor Review*, (June 1971).

The starting point for calculating the EOCL using the marginal product Forgone approach would be the alternative wage on the sugar cane plantation farms (W_c), while the supply price approach would begin with the market wage for work in the orange groves (W_o). We can assume that they do not pay income taxes or face any other significant distortions in their labor market. Other factors, however, could influence their decision to relocate to the new project. For example, the more pleasant climate of the orange growing region might translate into a reduced cost of living (C), which would allow the workers to maintain the same level of well-being with lower wages. Another factor might be a preference (S) of the workers to work in a more pleasant region.

For the purpose of this example, let us assume values of the wage and the other factors as follows:

$$\begin{aligned} W_o &= \$15.00 \text{ per day,} & W_c &= \$20.00 \text{ per day,} \\ C_o &= \$3.00 \text{ per day,} & C_c &= \$6.00 \text{ per day,} \\ S_o &= \$2.00 \text{ per day (value of the preference for the warmer region)} \end{aligned}$$

Using marginal product approach, we can calculate the EOCL for the new project as follows:

$$\begin{aligned} \text{EOCL} &= \text{prior wage} - \text{change in cost of living} - \text{worker preferences} \\ &= W_c - (C_c - C_o) - S_o \\ &= \$20 - (\$6 - \$3) - \$2 \\ &= \$15.00 \text{ per day} \end{aligned}$$

With the supply price approach we can arrive at the same value directly because we know that the market wage necessary to induce the workers to move to the new project in the orange-growing region (W_o) already accounts for the cost of living difference ($C_c - C_o$) and worker's regional preference for the better climate (S_o). Therefore, the EOCL is simply equal to the market wage in the region where the new job is located:

$$\text{EOCL} = W_o = \$15.00 \text{ per day}$$

This highly simplified example demonstrates that both methods for calculating the EOCL should produce the same result. However, in most circumstances it is difficult to place values upon complex factors such as cost of living differentials and worker's regional preferences. Uncertainties in the value of those factors make the marginal product Forgone approach cumbersome to use when information is scarce. Consequently, the straightforward supply price approach usually is an easier way to determine the EOCL.

12.3 Structure of Analysis in the Labor Market

The analysis of the EOCL presented here is structured around five sets of factors that are primary determinants in the cost of labor to the project. Labor prices can vary greatly from one project to the next, so we use the following classifications to help identify which of the determinants may have an effect on the labor costs of the project being evaluated.

1. Type of Labor (Skilled vs. Unskilled)
2. Regional Variations and Domestic Migration
3. Type of Job (Permanent vs. Temporary)
4. International Migration
5. Type of Labor Market (Protected vs. Unprotected)

First, an analytical distinction is made among skills and occupations. Classifying workers into relevant occupational categories is essential because of the enormous heterogeneity of the labor factor. In general, the lower the skill, the greater the likely homogeneity of labor within the skill or occupation category. Estimating the economic opportunity cost of unskilled labor is also made more straightforward by the frequent absence of distortions such as taxation or unemployment insurance in that part of the labor market. The skilled labor market, on the other hand, displays much greater heterogeneity and is frequently subject to multiple distortions which must be identified and accounted for in the estimation of the EOCL.

Second, regional migration induced by differences in wages, cost of living, and access to consumer goods and amenities also affects the EOCL for a project. Regional wage

differentials are a key consideration in the labor market where a rise in project employment in an urban setting has as its counterpart reductions of employment in rural areas that are traditional sources of migration. In such cases, distortions in the economy related to that migration must be accounted for when estimating the EOCL.

Third, one may also have to take international migration into account. This includes the case where the creation of jobs will retain workers who would have otherwise gone abroad or alternatively the case where foreign skilled workers are brought into the country to perform certain services.

Fourth, the estimation of the EOCL for a project must consider whether permanent or temporary employment will be created. Temporary positions in sectors such as tourism and construction lead to greater turnover in the labor market and create conditions for voluntary unemployment. This churning effect in the labor market results in additional costs to the economy which the EOCL should take into account.

Fifth, the rigidities imposed on the labor market through minimum wage laws, restrictive labor practices, high wage policies of state and multinational enterprises in some countries tend to create “protected sectors” in the labor market. In such a situation quasi voluntary unemployment and seasonal unemployment are common. In such situations the evaluations of the EOCL used by a project should reflect these special labor market conditions.

These five classifications within a labor market provide a framework for analyzing the complex concept of EOCL. In the rest of this chapter, we will begin by analyzing the EOCL for the simplest cases, i.e., unskilled rural labor, and then bring additional elements into account as they are needed in order to estimate the economic opportunity cost of labor for progressively more complex types encountered in the appraisal of actual projects.

12.4 The Economic Opportunity Cost of Unskilled Rural Labor

Some well-known growth models of underdeveloped countries have often taken the most extreme interpretation of the “marginal product forgone” hypothesis by placing a value of zero on the economic opportunity cost of unskilled labor in rural areas.⁶ As previously explained, those theories rely upon the assertion that because of a large quantity of unskilled rural workers, there is no economic opportunity cost to filling additional jobs.⁷ However, empirical evidence has been lacking that would support the idea that a surplus of idle, rural labor generally exists. In fact, a persuasive body of evidence is provided by researchers of rural economies indicating that when unskilled labor is not employed in the formal agricultural sector, it spends a large proportion of its time on other productive household and family farming activities. In this circumstance, the prevailing daily or weekly wage rate (the supply price of unskilled labor) is a reflection of the marginal productivity of this type of activity. Therefore, we can utilize the market wage as an effective measure of the value of the forgone marginal product of unskilled labor.⁸

When using the supply price of labor approach to calculate the EOCL, there is a series of steps which serves as a guide to the estimation process. The first step is to determine the minimum gross-of-tax wage (W) needed to attract sufficient unskilled labor to the positions available on the project. Second, distortions in the labor market such as income taxes or unemployment insurance benefits must be identified. Finally, the EOCL can be determined by adjusting the market wage to compensate for such distortions.

To demonstrate this process, two cases will be considered. In the first case, there are no seasonal variations in either the market wage rate or the demand for unskilled workers. The second example demonstrates how to estimate the EOCL when there are seasonal variations in the market wage rate and in the project’s demand for unskilled labor over the year.

⁶ Todaro, M.P., *Economic Development in the Third World*, New York: Longman, fourth edition, (1989), pp. 62-113.

⁷ Marglin, S.A., op.cit. pp. 10-23.

⁸ Harberger, A.C., “On Measuring the Social Opportunity Cost of Labor”, *International Labor Review*, (June 1971).

In the first case, we assume that there are no distortions in the unskilled labor market, i.e., there are no taxes paid by the employer (demand side) and no income taxes paid by the worker (supply side). We also assume that there are no fluctuations in wages or labor demand over time. It follows that the supply price of labor (W^s) is always equal to the prevailing market wage (W). Since there are no distortions, there is no need to make further adjustments to the market wage to estimate the EOCL. Consequently, the market wage rate for unskilled labor is the supply price of labor, which in turn is the economic opportunity cost of labor as shown in equation (12.2).

$$\text{EOCL} = W = W^s \quad (12.2)$$

Note that the EOCL is estimated using the market supply price (W^s) not the project wage (W_p). The project wage is the demand price and measures the financial cost of labor for a particular project, while the market wage measures the opportunity cost of the unskilled labor to the economy. If the demand price is higher than the market wage, then the difference is an economic externality which arises from the employment of this type of labor.

In the second case, the estimation of the EOCL of unskilled labor is done for a project which demands workers throughout the year while the market wage varies due to demand and supply factors affecting the local labor market. Using the supply price approach, we begin again with the market wage of unskilled labor for this type of project. There are no tax distortions. Due to the seasonal fluctuations in the market wage the economic opportunity cost of labor at any point in time will be calculated by the market wage rate (W_t) that corresponds to the period of time in which labor is hired by the project.

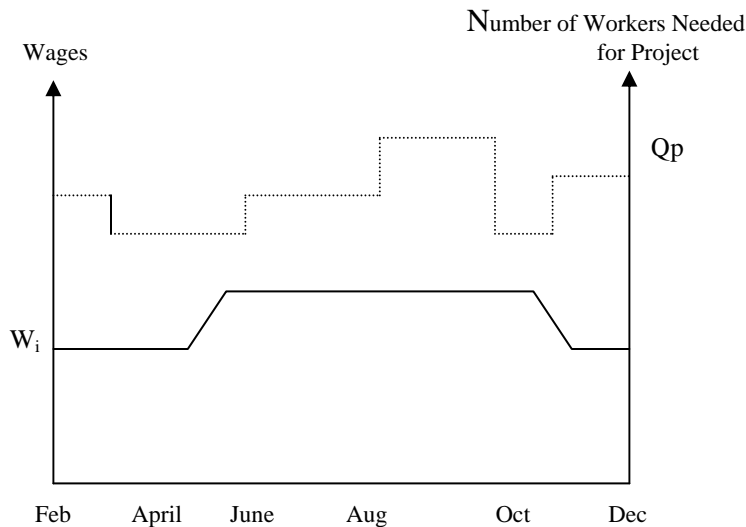
For example, if a region growing rice and sugar cane has a wage rate of \$5 per day during the off-season, it is possible that the wage could be many times higher during the harvesting seasons if they coincide. If a project is built based on the assumption that labor will be steadily available at \$5 per day, but instead it must compete for labor at a much higher rate during the harvest season, then the financial and economic viability of the project may be endangered.

These higher seasonal labor costs must be accounted for to arrive at an accurate estimate of the EOCL for the project. So too, seasonal variations in the size of the employed work force should be reflected in the calculation of the wage. It is a common condition in rural areas that both the demand for unskilled labor and the market wage rate have pronounced seasonal patterns as illustrated in Figure 12.1. Equation (12.2) deals with this situation by defining the total economic cost of labor used by a project over a year as the product of the quantity of labor hired in each season or wage period times the corresponding market wage rate (supply price) for the period. This is equal to the sum of the unskilled wage rate for each particular season or wage period (W_t) times the total amount of unskilled labor employed by the project in that period (L_t):

$$EOCL = \sum_{t=1}^n (L_t W_t) \tag{12.3}$$

where 't' denotes the period of time and 'n' denotes the total number of periods.

Figure 12.1: Effect on the Economic Opportunity Cost of Labor of Seasonal Variations in Wages and Labor Demand in Rural Regions



Where

- Pattern of project's demand for labor during the year
- Pattern of wage rate for unskilled labor during the year

If the project's demand for labor is relatively high in the off-season, then the total economic cost of labor will be lower than if the project's demand for labor coincides with the seasonal peak demand for this labor.

Consider the case of undertaking a labor-intensive sugar project.⁹ The project requires unskilled workers on a temporary basis and pays a wage of \$180 per month (W_p). The working conditions are identical to those prevailing in the labor market. Table 12.1 shows the project's monthly requirements for people in column (3) and the monthly market wage rates in column (2) that labor would be willing to work for on this project.

Table 12.1
Market Wages and Project Demand for Seasonal Labor

Month	Market Wage (\$/month)	Person-months Required by project	EOCL for Period (\$)
(1)	(2)	(3)	(4)
January	120	18	2,160
February	100	18	1,800
March	180	18	3,240
April	180	9	1,620
May	100	9	900
June	150	0	0
July	180	0	0
August	120	0	0
September	150	0	0
October	110	0	0
November	150	9	1,350
December	<u>180</u>	<u>9</u>	<u>1,620</u>
Total	-	90	12,690

In this case, the monthly market wage rates are the supply prices of unskilled labor to the sugar project. Then using equation (12.3) the EOCL is calculated as follows:

⁹ Examples are based upon work done by Jenkins, G.P. and El-Hifnawi, M.B. in *Economic Parameters for the Appraisal of Investment Projects: Bangladesh, Indonesia and the Philippine*, Manila: Asian Development Bank, (1993).

$$\begin{aligned}
 \text{EOCL} &= \sum_{t=1}^{n=12} (L_t W_t) \\
 &= 120*18 + 100*18 + \dots + 150*9 + 180*9 \\
 &= \$ 12,690
 \end{aligned}$$

The project wage (W_p) paid does not play a direct role in the estimation of the economic opportunity cost of labor. The wage paid by the project is the financial cost to the project. The difference between the financial cost and the economic opportunity cost is the value of the labor externality.

12.5 The Economic Opportunity Cost of Skilled Labor

Skilled labor is not a homogeneous factor, nor is the financial cost and economic opportunity cost going to be the same for all types of such labor. There is no doubt that securing adequate supplies of labor with the appropriate skills is a key determinant of the success of most projects. Post-evaluations of development investments have demonstrated that projects are often seriously delayed or even abandoned because of an inadequate supply of labor with specific skills. Hence, special attention needs to be paid to the determination of the sources of supply, levels of compensation, and potential distortions in these labor markets.

To meet a project's requirements, labor are often induced (with higher wages and better living environment) to migrate from other areas. For example, skilled workers in urban areas are able to obtain many goods and services, such as better education for their children that are more readily available in the city. If called up to move from an urban to a rural area, they may well require a wage premium to be paid, in spite of the fact that simple food items are cheaper in the countryside.

The supply price approach for determining the economic opportunity cost of labor for skilled occupations uses the same basic steps as outlined in the unskilled case. We begin by determining the market supply price of labor (W^s) needed to attract the workers to the project.

Then, distortions to that wage are identified and quantified. The EOCL can be estimated by adjusting W^s to account for those distortions.

To demonstrate this approach, we will estimate the EOCL for three situations. The first example is simplified by using the somewhat unrealistic assumptions that there are no distortions in the market for labor and that the project provides jobs with the same working conditions as other employers of these occupations in the area. Furthermore, no workers need to (or can) be attracted from outside the area. The second case drops those assumptions and considers a situation where labor must be induced to move from alternative projects or regions where there are market distortions. Finally, we will examine a case which demonstrates how employment which lasts for less than the full year can be a factor in determining the value of the economic opportunity cost of any particular type of skilled labor.

(i) Labor Market without Distortions or Regional Migration

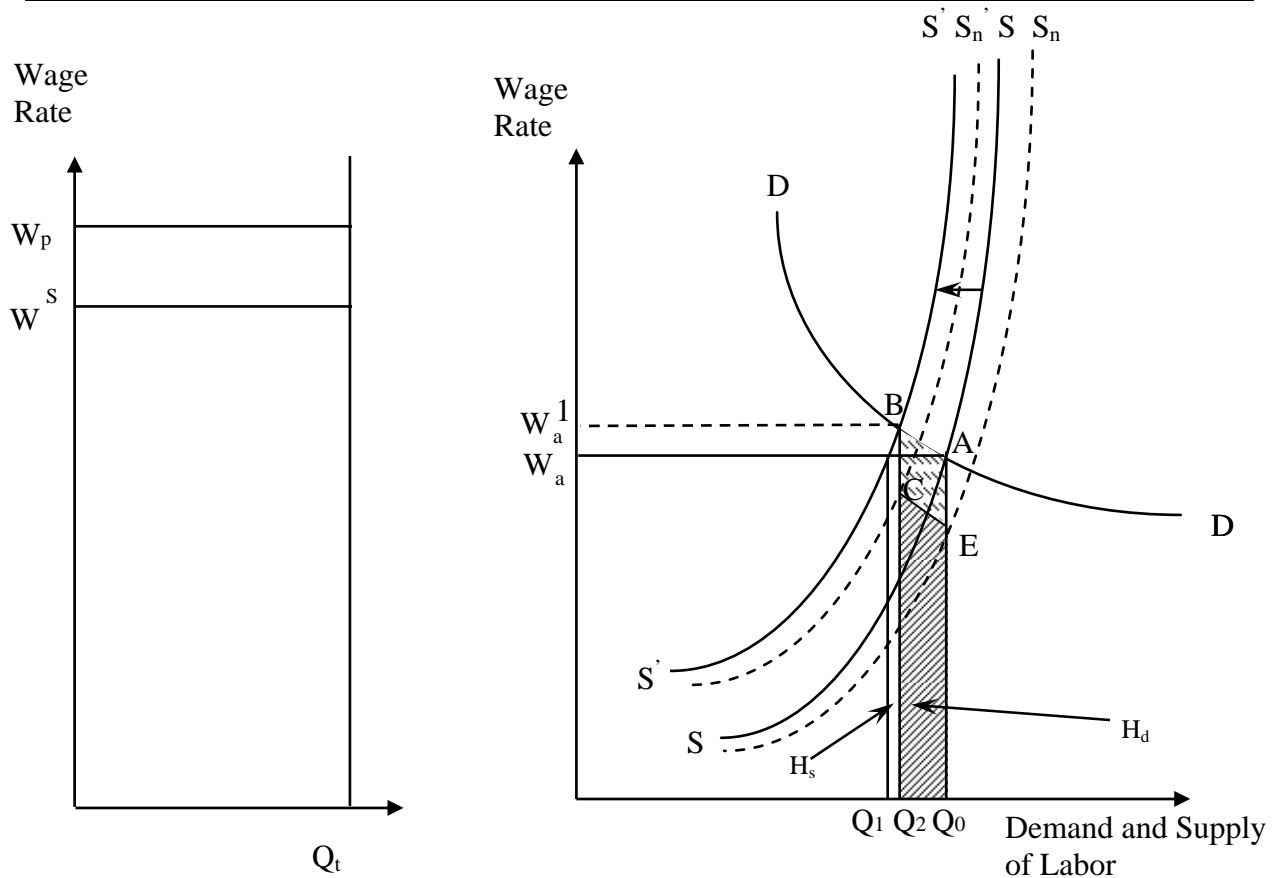
If there are no distortions in the market such as income tax on the wages for a given occupation, and if the employment provided by the project has the same working conditions as alternative employment in the region, then it does not matter whether the new hires come from other employment (reduced demand) or from non-market activities (new supply). In both cases the economic opportunity cost is equivalent to the local market wage (W) which is the supply price (W^s).

This is exactly the same result as in the case of the unskilled rural labor. In fact, the analysis of the EOCL is not differentiated so much by the skill level of the worker as by the nature of the distortions in the labor market. In the case of skilled occupations it is more realistic to assume that we will have to pay a higher wage to attract such labor away from other jobs that have different working conditions and/or are located in other regions which have distorted labor markets.

(ii) Workers Migrate to Project from Distorted Regional Labor Markets

Suppose a project hires labor, and some of the workers are induced to migrate from alternative employment in other labor markets. For each occupational type the project pays a wage equal or higher than the gross-of-tax supply price (W_g^s) to attract adequate numbers of workers. As demonstrated by Figure 12.2, the migration of workers from the other regions to the project will shift the labor supply curve leftward to the new position $S'S'$ from SS . This shift intersects the demand curve (DD) at a higher equilibrium wage rate at B from A , causing a decrease in the demand for the current employment from Q_0 to Q_1 .

Figure 12.2: Regional Interaction between Skilled Labor Markets



Quantity of Labor Required for Project

Market for a Type of Skilled Labor in Sending Region

$$H_s = \frac{Q_2 - Q_1}{Q_0 - Q_1} \quad H_d = \frac{Q_0 - Q_2}{Q_0 - Q_1}$$

At the same time, the higher wage rate may induce some skilled workers to enter the formal labor force, or more overtime to be worked, thereby increasing the quantity of skilled labor supplied from Q_1 to Q_2 . The net effect is that even if all of the labor for the project migrates from the sending regions, a proportion of the labor (H_S) ultimately comes from the newly induced supply and a proportion (H_d) comes from the reduced demand for workers elsewhere.¹⁰

The reduction in the quantity of labor employed elsewhere (i.e., $Q_0 - Q_2$) results in a loss of personal income taxes to the government, which is shown as the area bounded by ABCE that is also the same as the area measured by the vertical difference between the gross-of-tax supply curve, SS, and the net-of-tax supply curve, S_nS_n , multiplied by the change in employment ($Q_0 - Q_2$). When calculating the EOCL, only the tax loss resulting from the reduced demand (H_d) need to be accounted for, because we assumed that the increased supply (H_S) of labor is coming from market or non-market activities where there are no taxes or other distortions. Thus the EOCL for the project in such cases is the gross-of-tax supply price (W_g^S) of workers induced to move to the area minus the difference between the income taxes the workers would pay on this gross-of-tax supply price of labor ($W_g^S T$), which are gained by the government, and the income taxes previously paid by the workers in their alternative employment ($H_d W_a T$), which are lost by the government. For simplicity, we assume the tax rates this worker pays on the supply price and alternative wage in the sending region are the same although they don't have to.

The economic cost of skilled labor hired by the project in the area can be expressed as follows:

$$EOCL = W_g^S - (W_g^S T - H_d W_a T) \quad (12.4)$$

¹⁰ For a further development of some of these issues, see Bell, Clive, "Regional Heterogeneity, migration, and shadow prices", *Journal of Public Economics*, North-Holland, Vol. 46, (October 1991); and Gemmel, N. and Papps, I., "The Shadow Wage in Economies with Migrant Labor: The case of Labor as a Traded Good", *The Manchester School*, Vol.60, No. 1, (1991).

where H_D denotes the proportion of the project's demand for labor obtained from taxed employment activities in the alternative labor market;

W_a denotes the gross-of-tax wage of labor from alternative sources;

W_g^s denotes the gross-of-tax supply price of labor; and

T denotes the income tax rate levied on workers in all regions.

In this situation, $H_S = (1 - H_D)$ includes both the supply of labor coming to the region from untaxed market and non-market activities, as well as increases in the labor force participation and the number of hours worked. While it is theoretically possible for a project to change the level of labor force participation or the number of hours worked, this effect over the lifetime of a project is likely to be small, depending upon the type of skill and the market at the time of project recruiting.

Consider again the sugar project discussed above. In addition to the unskilled workers hired for the project, the government requires each year 1,000 person-months of labor with skilled occupations. Due to a shortage of such workers in this region, the project will have to attract them from the urban areas surrounding the region where the project is located. Let us assume that despite the fact that these workers earn a monthly gross-of-tax salary (W_a) of \$900 in the urban area, they will not work for less than \$1,200 gross-of-tax for the project (W_g^s). These wage rates reflect the gross-of-tax supply prices of the workers in the two markets, respectively. Suppose there is a policy of encouraging more workers in these occupations to migrate to the rural areas, so the project is required to pay a higher salary (W_p) of \$1,500 per month for such labor, or \$300 more than the supply price. All skilled workers pay 20% of their wages in income taxes.

Using equation (12.4), we can estimate the economic opportunity cost of this labor to the project by determining: (1) the taxes to be paid on the supply price of skilled labor for the project, and (2) the taxes forgone by the workers in their alternative employment.

(1) Taxes on the Supply Price of Labor

$$W_g^s T = 1,200 \cdot (0.20) = \$240/\text{month}$$

(2) Taxes Forgone in Alternative Employment

Let us assume that the supply of labor in these occupations in the economy is relatively inelastic as compared to the demand for that labor and let $H_d = 0.90$ and $H_s = 0.10$. Hence, we can anticipate that approximately ninety percent of the project's labor requirements will ultimately be sourced from the decrease in the quantity of labor employed elsewhere, while the remaining ten percent of the project's needs will be met through increased labor force participation due to the new project's higher wage. The forgone taxes from the previous employment of the workers are calculated as follows:

$$H_d W_a T = 0.90 * 900 * 0.20 = \$162/\text{month}$$

Combining those two parts with the supply price, the economic opportunity cost of the labor used by the project in this rural area is calculated from equation (12.4) as follows:

$$\begin{aligned} \text{EOCL} &= W_g^s - (W_g^s T - H_d W_a T) \\ &= 1,200 - [(1,200 * 0.20) - (0.90 * 900 * 0.20)] \\ &= \$1,122/\text{month} \end{aligned}$$

The difference between the economic opportunity cost of labor and the project wage represents the value of the project's labor externality per month of labor employed. Following equation (12.1), the labor externality for the above case can be expressed as:

$$\begin{aligned} \text{LE}_i &= W_p - W_g^s + (W_g^s T - H_d W_a T) \\ &= W_p(1 - T) - W_g^s(1 - T) + W_p T - H_d W_a T \end{aligned}$$

Carrying this analysis one step further, we can determine how these labor externalities are distributed between the workers and the government. The benefits to each can be calculated as follows:

$$\begin{aligned}
 \text{Labor benefits} &= W_p(1 - T) - W_g^s(1 - T) \\
 &= 1,500 \cdot (1 - 0.20) - 1,200 \cdot (1 - 0.20) \\
 &= \$240/\text{month}
 \end{aligned}$$

$$\begin{aligned}
 \text{Government benefits} &= W_pT - H_d W_aT \\
 &= 1,500 \cdot (0.20) - (0.90 * 900 * 0.20) \\
 &= \$138/\text{month}
 \end{aligned}$$

Thus, of the total of externalities created per month by the employment of workers by a project, labor will gain an additional \$240 per month while the government will capture \$138 per month in additional taxes. The distributional analysis provides a means of evaluating the financial gains and losses affecting groups in the economy other than the owners of the project.

12.6 The Economic Opportunity Cost of Labor When Labor is not Employed Full Time

In this analysis, workers are not divided between those who are working in the formal labor market and those who are not. Instead, we postulate that each worker could spend part of each year in non-market activities or unemployment. Workers now can expect to be employed in market activities for a proportion (P_p) of the year if they work for the project. If they are not associated with the project, they will be employed a different proportion (P_a) of the year. When they are not working in the formal labor market, they will be engaged in non-market activities outside the project or in alternative regions, i.e., $(1 - P_p)$ and $(1 - P_a)$ proportions of their labor force time, respectively.

Let us again denote the gross-of-tax supply price of skilled labor in the area of the project as W_g^s and the alternative wage, which reflects this labor's other opportunities as W_a . From the supply price approach, the EOCL is equal to the gross-of-tax expected supply price for labor (W_g^s), but only working a portion of the year on the project (P_p), minus the additional tax payments that the worker would incur if earning her supply price wage W_g^s on this project.

This additional tax is the difference between the tax paid on the project ($P_p W_g^s T$) and the tax previously paid in the alternative mix of market activities ($H_d P_a W_a T$). The taxes lost in alternative market activities arise because there is a net reduction in employment of this type of worker elsewhere. We assume that workers do not pay taxes on non-market activities. Using the supply price approach, the economic opportunity cost of these workers is the expected gross-of-tax supply price less the expected net change in tax payments. It can be expressed as equation (12.5):

$$\text{EOCL} = P_p W_g^s - (P_p W_g^s T - H_d P_a W_a T) \quad (12.5)$$

Suppose in this case the alternative wage rate for skilled labor is $W_a = \$600/\text{month}$, and the project wage is equal to the gross-of-tax supply price paid to induce labor to move to the project area ($W_g^s = W_p = \$800/\text{month}$). The tax rate on skilled labor in all locations is 20%. All of the labor is obtained from alternative employment ($H_d = 1$) with the proportion of time employed in the alternative areas (say, $P_a = 0.8$). Assuming that a skilled worker expects to be employed in the project and the project region is $P_p = 0.9$, the economic opportunity cost of labor in this rural project would be:

$$\begin{aligned} \text{EOCL} &= 0.9 \cdot (800) - [0.9 \cdot (800) \cdot (0.20) - 1.0 \cdot (0.8) \cdot (600) \cdot (0.20)] \\ &= 720 - (144 - 96) \\ &= \$672/\text{month} \end{aligned}$$

While the financial cost of labor to fill a job (which employs someone for 90 percent of the year) is estimated on average to be \$720 ($= P_p W_p$) per period, we find that the economic

opportunity cost of labor is only \$672 per month, or \$48 less than the financial cost. This difference is the net tax gain to the government.

We now extend from the analysis when workers were employed less than full time in market activities during a typical year. This is especially important in the case of countries with high unemployment compensation payments, such as Canada and the countries of Northern Europe.¹¹ We differentiate between those engaged in full-time employment and those who have a work history characterized by a succession of work experiences interspersed with unemployment. Because of their choice of occupation or their level of seniority, people in the permanent (or full-time) employment sector are almost never unemployed. On the other hand, workers employed by temporary sectors such as tourism and construction are in jobs that are not expected to be associated with continuous employment. For this analysis, individuals expected to experience periodic spells of unemployment or non-market time are included in the temporary labor force, both when they are working and when they are unemployed.

When evaluating projects, one further question we want to consider is what is the quality of the jobs being created?¹² We need to classify the type of job by the type of employment they provide. Are the jobs full-time for the entire year (i.e., permanent sector) or will they employ a given worker for only part of the year (i.e., temporary jobs)? Temporary jobs are those that do not retain the workers for a full year but intersperse spells of unemployment or non-market activities with employment. Permanent jobs provide full-time employment year round.

The type of employment being created is important because temporary jobs can have a high economic cost when unemployment insurance payments (or other forms of social security) are paid to these workers when they are engaged in non-market activities, including being unemployed.¹³ Hence, unemployment insurance needs to be accounted for in the appraisal of a project that creates these jobs.

¹¹ In those countries, the unemployment benefits vary from 55% and 75% of lost wage in Canada and Sweden, respectively, to as high as 90% of the previous daily wage in Finland.

¹² Jenkins, G.P. and Kuo, C.Y., "On Measuring the Social Opportunity Cost of Permanent and Temporary Employment", *Canadian Journal of Economics*, Vol. 9, No. 2, (May 1978).

¹³ Broadway, R.W. and Flatters, F., "The Efficiency Basis for Regional Employment Policy", *Canadian Journal of Economics*, Vol. 14, No. 1, (February 1981).

Let us consider first the creation of permanent jobs. When a project creates new permanent jobs, they will generally be filled by individuals already working in alternative permanent sector jobs, other temporary sector jobs, or some being hired who are currently out of the labor force. We denote these proportions as H_d^p , H_d^t and H^s , respectively, where $H_d^p + H_d^t + H^s = 1$. For those being sourced from alternative jobs in the permanent sector, there will be an externality arising from the loss in income tax receipts from the reduction of employment in these activities. For those sourced from the temporary sector there will be a savings in the unemployment insurance now being paid to the temporary sector worker when he is unemployed. At the same time, there is a loss of any taxes he would have paid while working. For the proportion of the jobs that are filled from people who were previously out of the labor force there will be no externalities that need to be included. Therefore, the EOCL of a permanent job can be expressed as follows:

$$EOCL^P = W_g^S(1 - T) + H_d^p W_p T + H_d^t [P_t W_t T - (1 - P_t) f U (1 - T)] \quad (12.6)$$

where W_g^S denotes gross-of-tax supply price of labor to the project;

W_p denotes gross-of-tax wage earned in alternative jobs in the permanent sector;

W_t denotes gross-of-tax wage earned in the temporary sector;

P_t denotes proportion of time a member of the temporary sector worker expects to be employed during a calendar year;

T denotes personal income tax rate;

f denotes proportion of time an unemployed worker expects to collect unemployment benefits; and

U denotes unemployment insurance benefits.

If there is no unemployment insurance (like in Indonesia or Vietnam), then $f = 0$. Equation (12.6a) will then measure the opportunity cost of labor to fill a permanent job as:

$$EOCL^P = W_g^S(1 - T) + H_d^p W_p T + H_d^t P_t W_t T \quad (12.6a)$$

On the other hand, when a year's worth of additional employment is created in the temporary sector of a labor market, these workers will be sourced from the permanent sector, the temporary sector and from those previously out of the labor force, in the proportions H_d^p , H_d^t and H^s , respectively. In this situation, suppose P_t is the proportion of time that any one person actually works in a temporary sector job during a year. As temporary jobs are created, and people are attracted to them from the permanent sector, these people will now experience periods of unemployment and collect unemployment insurance. For each period of labor services sourced from the permanent sector, there will be associated with it $1/P_t$ individuals and $(1-P_t)/P_t$ periods of unemployment. This will give rise to $(1-P_t)/P_t$ periods of paid unemployment insurance compensation. For labor services sourced from those already in the temporary sector then the loss in taxes will be for the same length of time as the time working on the project, and the amount of unemployed time and unemployment insurance compensation will also be the same as before. The economic opportunity cost of labor related for a year's worth of temporary sector jobs will then be equal to:

$$EOCL^T = W_g^s(1-T) + (H_d^p/P_t)[W_p T + (1-P_t)fU(1-T)] + H_d^t W_t(T) + H^s[(1-P_t)/P_t]fU(1-T) \quad (12.7)$$

In the case where the wage rates paid for both temporary and permanent jobs were the same, then the economic cost of (12 months) of temporary jobs would be greater than for a year of a permanent job because of the greater amount of taxes that would be lost and the greater amount of unemployment insurance payments associated with these jobs.

12.7 International Migration and the Economic Opportunity Cost of Labor

Until recently, labor has been considered a non-internationally traded service. However, this is changing as more and more workers are relocating to other countries to sell their skills and services. There are two such cases, one is retention or returned migrants and another is foreign workers.

(i) Retained or Returned Migrants

This is particularly true for countries such as the Philippines, Egypt and Sri Lanka where large numbers of skilled and semi-skilled workers are regularly employed abroad for substantial periods of time. In such a situation when a project is created inside the country and additional labor of certain occupations is hired, we would expect to find a part of this labor to be sourced from a reduction in the outflow of international migration. When this occurs the economic opportunity cost of labor must not only take into consideration the adjustment of the demand and supply of labor in the local markets, but also any distortions associated with the retention or return of migrants who would have been employed abroad.

It is quite common when a country's citizens work abroad for them to send back a stream of payments in the form of personal savings or remittances to relatives. Following the supply price approach to the EOCL, the reduction in remittances is not an economic cost, as they will be factored into the worker's supply price to the project. However, adjustments need to be made to the supply price, as the foreign remittances are spent locally to generate additional consumption taxes such as VAT and also the remittances are made in foreign exchange in which a foreign exchange premium exists in most countries. Taking both the local and international labor markets adjustment into account the expression for the EOCL becomes,

$$EOCL = W_g^s(1 - T) + H_d W_a T - H_f R t_{VAT} + H_f R \left(\frac{Ee}{Em} - 1 \right) \quad (12.8)$$

where H_d denotes proportion of the project's demand for a given type of labor obtained from taxed employment activities in the domestic market;

H_f denotes proportion of the project's demand for a given type of labor sourced from reduced international out-migration;

t_{VAT} denotes value-added tax rate levied on consumption;

R denotes the average amount of remittances (measured in local currency) that would have been made per period if this type of worker had been employed abroad; and

$\left(\frac{Ee}{Em} - 1 \right)$ denotes rate of the foreign exchange premium as a fraction of the value of amount that would otherwise have been remitted.

When we recognize that part of the sourcing of the workers for a project is through an adjustment in the international migration of workers, we recognize that there are the share of workers being sourced from alternative domestic activities ($H_d = 0.6$), and the proportion sourced from changes in international flows of labor $H_f = 0.3$. Let us consider the same example in Section 12.5 and the VAT rate is 15%. Also assume that on average these workers would have remitted \$500 per period, and the foreign exchange premium is 6 percent. Applying equation (12.8) we find that the EOCL is as follows:

$$\begin{aligned} \text{EOCL} &= W_g^s (1 - T) + H_d W_a T - H_f R t_{\text{VAT}} + H_f R \left(\frac{Ee}{Em} - 1 \right) \\ &= 1,200 \cdot (1 - 0.2) + 0.6 \cdot (900) \cdot 0.2 - 0.3 \cdot (500) \cdot (0.15) + 0.3 \cdot (500) \cdot (0.06) \\ &= \$1,054.5 \end{aligned}$$

The EOCL of \$1,054.5 is less than it was previously, both because it is assumed that the potential migrant labor would not remit to the project country as much as they would have earned domestically, and the rate of foreign exchange premium is less than the assumed rate of domestic personal income tax.

(ii) Foreign Labor

In countries where the labor shortage is particularly acute, it may be necessary to import foreign labor to work on projects. Examples of this practice can be seen in both developing and developed countries where the demand for labor exceeds the supply. Often foreign workers are brought into the country by corporations or governments to work on projects requiring their skills. In developing countries this often takes the form of skilled advisors or technical staff, while in developed countries guest workers or unskilled laborers are imported to fill gaps in the labor pool. There is an economic opportunity cost associated with this foreign labor (EOCL^f) which should be included in the project assessment.

The EOCL^f is the net-of-tax wage paid to the foreign worker plus adjustments to the amount of foreign exchange associated with the repatriated portion, and adjustments to the amount of value-added tax (VAT) associated with consumption by the foreign workers using the non-

repatriated portion of that wage, plus any subsidies the foreign workers may benefit from while in the country. The repatriated portion of the wage should be adjusted to account for the true cost of the foreign exchange to the economy rather than just its market value. This is necessary because the value of the foreign exchange may be distorted. While living in the country, foreign workers have to use a portion of their wage for consumption. The incremental amount of VAT revenue paid due to the foreign workers' consumption in the country should be accounted for as an economic benefit to the country as the country gains from the local consumption of the foreign workers. At the same time, foreign workers may benefit from government subsidies on a variety of items such as food, fuel, housing or health care. The amount of benefit foreign labor gets from those subsidies should be accounted for as an economic cost to the country. Algebraically, the economic opportunity cost of foreign labor can be expressed as:

$$EOCL^f = W^f(1 - T_h) - W^f(1 - T_h)(1-R)t_{VAT} + W^f(1 - T_h)R\left(\frac{E^e}{E^m} - 1\right) + N \quad (12.9)$$

where W^f denotes gross-of-tax wage of foreign labor;

T_h denotes personal income tax levied by the host country on foreign labor;

t_{VAT} denotes value-added tax rate levied on consumption;

R denotes proportion of the net-of-tax income repatriated by foreign labor;

E^e denotes the economic cost of foreign exchange;

E^m denotes market exchange rate; and

N denotes value of benefits gained by foreign workers from subsidies.

If the $EOCL^f$ is greater than the financial cost of labor to the project, then the second term must be smaller than the sum of the third and fourth terms implying that the economic benefit created by foreign consumption in the country can not offset the foreign exchange premium related to the remitted portion of their wage and the cost of government's subsidies. In this case, the economic opportunity cost of hiring foreign labor will be greater than the project wage. If the second term is greater than the third and fourth terms, however, the economic opportunity cost of foreign labor will actually be lower than the market wage, which means that the country is benefiting economically from the presence of foreign labor.

Suppose a multinational corporation considers an electronic assembly project in an urban area and discovers that there is insufficient local labor. It decides to import skilled workers from a nearby country to operate the project until enough local workers could be trained for the production requirements. The shortfall estimated to be equivalent to 50 workers who will be paid \$200 per month. That wage will be subject to a 25% personal income tax. Each worker is expected to repatriate 30% of her net-of-tax income to support family members at home. The VAT rate is 15%. The market exchange rate is held constant by the government while the economic exchange rate is estimated to be 6% higher than the market value. In this case, we assume that there are no subsidies paid by the government with respect to these workers, i.e., $N = 0$.

Applying those values to the equation (12.9), we estimate the economic opportunity cost of foreign labor to be:

$$\begin{aligned} \text{EOCL}^f &= 200 \cdot (1 - 0.25) - 200 \cdot (1 - 0.25) \cdot (1 - 0.30) \cdot (0.15) + 200 \cdot (1 - 0.25) \cdot (0.30) \cdot (0.06) \\ &= \$136.95/\text{month} \end{aligned}$$

This analysis shows that the economic opportunity cost of each worker will be \$63.05 less than the gross-of-tax wage of \$200. Hence, a substantial external benefit is generated by this use of foreign labor.

12.8 Effects of a Protected Sector on the Economic Opportunity Cost of Labor

Until now our analysis has focused on estimating the EOCL in competitive labor markets. In many countries, however, there is a segmentation of the urban labor market between a protected sector and an unprotected or open sector.¹⁴

¹⁴ In the discussion of the EOCL for the protected sector we begin with the approach followed by Edwards, A.C., "Labor Supply Price, Market Wage, and the Social Opportunity Cost of Labor", *Economic Development and Cultural Change*, Vol. 38, No.1, (October 1989). See also, Bicak, H.A., Jenkins, G.P., Kuo, C.Y. and Mphahlete, M. B., "An Operational Guide to the Estimation of the Economic Opportunity Cost of Labour in South Africa", *South African Journal of economics*, Vol. 72:5, (December 2004).

The protected sector is usually made up of the government agencies, foreign companies, and large local firms which provide wages (W^P) above the market clearing wage. The higher wages offered by these types of employers are often the result of stricter compliance with minimum wage laws, powerful unions which are able to demand and get significantly higher wages, government policies that give higher wages to civil servants, or foreign companies which pay high wages to decrease possible resentment by workers and politicians in the host country. Consequently, employment in the protected urban labor force is highly desired, with a variety of rationing methods used to select the people to fill the limited number of positions.

The open labor market is typically affected by fewer distortions to the supply price of labor (W^O). Wages are determined competitively in the market place where there are fewer barriers to entry, lower wages and less security of employment. While workers may be initially attracted to this labor market by the hope of finding a job in the protected sector, they often end up working in the open labor market.

The phenomenon of chronic unemployment, at rates far in excess of what might be explained in terms of normal friction in the economy, has been attributed, in part, to the existence of a protected labor market. A portion of those chronically unemployed workers are attempting to gain access to the protected sector, but at the same time are unwilling to work for the lower wages offered by the open labor market. This unwillingness to work at the open market wage creates sub-sectors in the labor market where quasi-voluntary and search unemployment exists.

(i) *EOCL in the Protected Sector and No Migration*

The characteristics of unemployment in this situation are shown in Figure 12.3A. If the overall supply of labor to the market is given by the supply curve (SS^T), the total number of workers making themselves available for work at the protected sector wage of W_1^P is shown as point C. The number of protected sector jobs available is much more limited at Q^P (i.e., BC). Hence, there is an excess supply of labor available at the protected sector wage, as shown by the quantity B. If the selection of workers for employment in the protected sector is

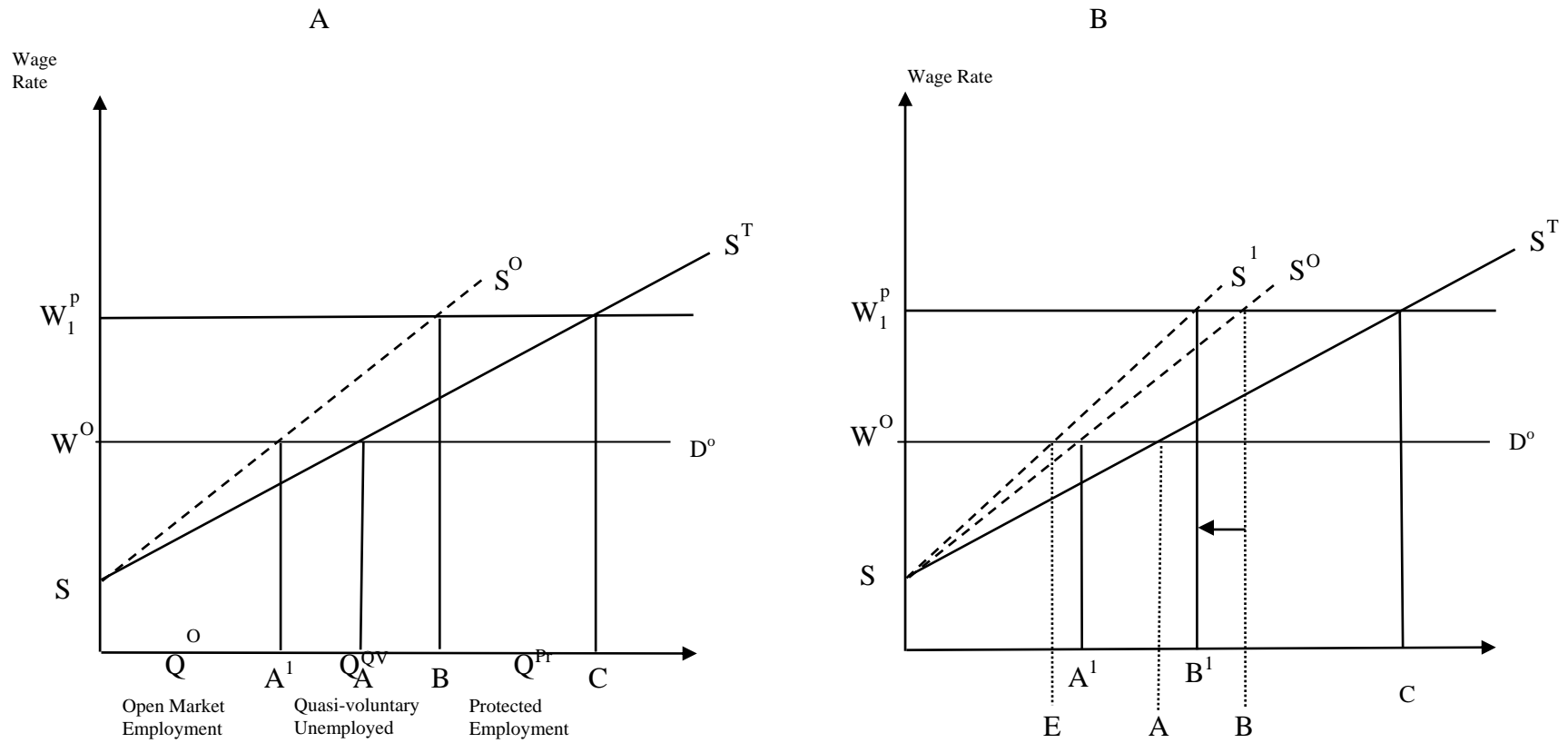
done in a random fashion from the available workers, independent of their supply prices, it follows that the supply of labor available to the open market will be a fraction (B/C) of the total labor supply SS^T at each wage rate. This labor supply is shown as the curve SS^O .

To simplify our analysis for this case, we assume that the demand for labor in the open sector is perfectly elastic at a wage rate of W^O , intersection of the demand for labor in the open sector ($W^O D^O$) with the supply (SS^O) determines the quantity employed in the open market. This quantity is indicated by point A^1 . The quantity of labor classified as unemployed (Q^{QV}) is determined from the difference between points A^1 and B . These quasi-voluntary unemployed are those workers that will not choose to take jobs in the open market sector because their basic supply price of labor is above the open market wage (W^O). They actively seek jobs in the protected sector, and will consider themselves involuntarily unemployed. They are seeking work which will pay the protected sector wage (W_1^P), but are unable to find it.

If we add a project to the protected sector, then as shown in Figure 12.3B, the size of the protected sector increases from $(C-B)$ to $(C-B^1)$. If again these additional workers $(B-B^1)$ are selected randomly from those remaining who want to work in the protected sector, the supply of labor to the open market will now shift to the left from SS^O to SS^1 . The number of workers willing to take jobs in the open sector will fall from A^1 to E . When we attract workers from the unemployed and open sectors in proportion to their numbers in the labor pool, in the absence of any distortions, then the economic opportunity cost of labor to this project is a weighted average of the open sector wage (W^O), and the average supply price of the quasi-voluntary unemployed $[(W^O + W_1^P)/2]$. The relevant weights are the proportions that people in each of those categories will be chosen for the protected sector jobs. Under a random selection method, the weights are the fraction that the open sector employment is of the total supply of labor not working in the protected sector (A^1/B), and the fraction that the quasi-voluntary unemployed is of the total labor force not working in protected sector, $(B-A^1)/B$. Hence, the EOCL for protected sector jobs is given by the expression:

$$EOCL^P = (W^O) * (A^1/B) + [(W^O + W_1^P)/2] * [(B - A^1)/B] \quad (12.10)$$

**Figure 12.3: Estimating the Economic Opportunity Cost of Labor for Protected Sector Jobs
(One Protected Sector and $\eta = \infty$)**



If we denote Q^O as the quantity employed in the open market, and Q^{QV} as the amount of quasi-voluntary unemployment before the creation of these additional protected sector jobs, we can write the expression for the economic opportunity cost of protected sector jobs as:

$$EOCL^P = W^O * [Q^O / (Q^O + Q^{QV})] + [(W^O + W_1^P) / 2] * [Q^{QV} / (Q^O + Q^{QV})] \quad (12.10a)$$

When income taxes are levied on wages in both the protected and open sectors, the economic cost of hiring workers from the open sector is the gross-of-tax wage they were earning in the open sector W^O , because the taxes on this labor will now be lost. For the quasi-voluntary unemployed hired by the protected sector, their economic opportunity cost is still the average of the net-of-tax open and protected sector wages because they pay no taxes when unemployed. To account for these lost taxes, equation (12.10a) can be rewritten as follows:

$$EOCL^P = W^O [Q^O / (Q^O + Q^{QV})] + [(W^O + W_1^P) / 2] (1-T) [Q^{QV} / (Q^O + Q^{QV})] \quad (12.10b)$$

(ii) EOCL with Two Protected Sectors

More realistically, one can think of the protected sector as containing a series of segmented markets, with different protected sector wages, W_1^P , W_2^P , ..., W_i^P . Figure 12.4A portrays the same labor market that we dealt with above with one protected sector. To simplify the analyses somewhat, we assume that the demand for labor in the open sector is perfectly elastic. Furthermore, we assume that there are no distortions in the labor market (i.e. taxes and subsidies).

As we have seen previously, when the first protected sector is introduced at a wage of W_1^P the total number of workers making themselves available for work at the protected sector wage will be given at point C. After the jobs in the first protected jobs are filled, the total number of workers employed in the open sector is given by point A¹ in Figure 12.4B. Suppose now additional protected sector jobs are created where the wage (W_2^P) paid is higher than the open wage, but below that of the first protected sector. For the moment also assume that there are

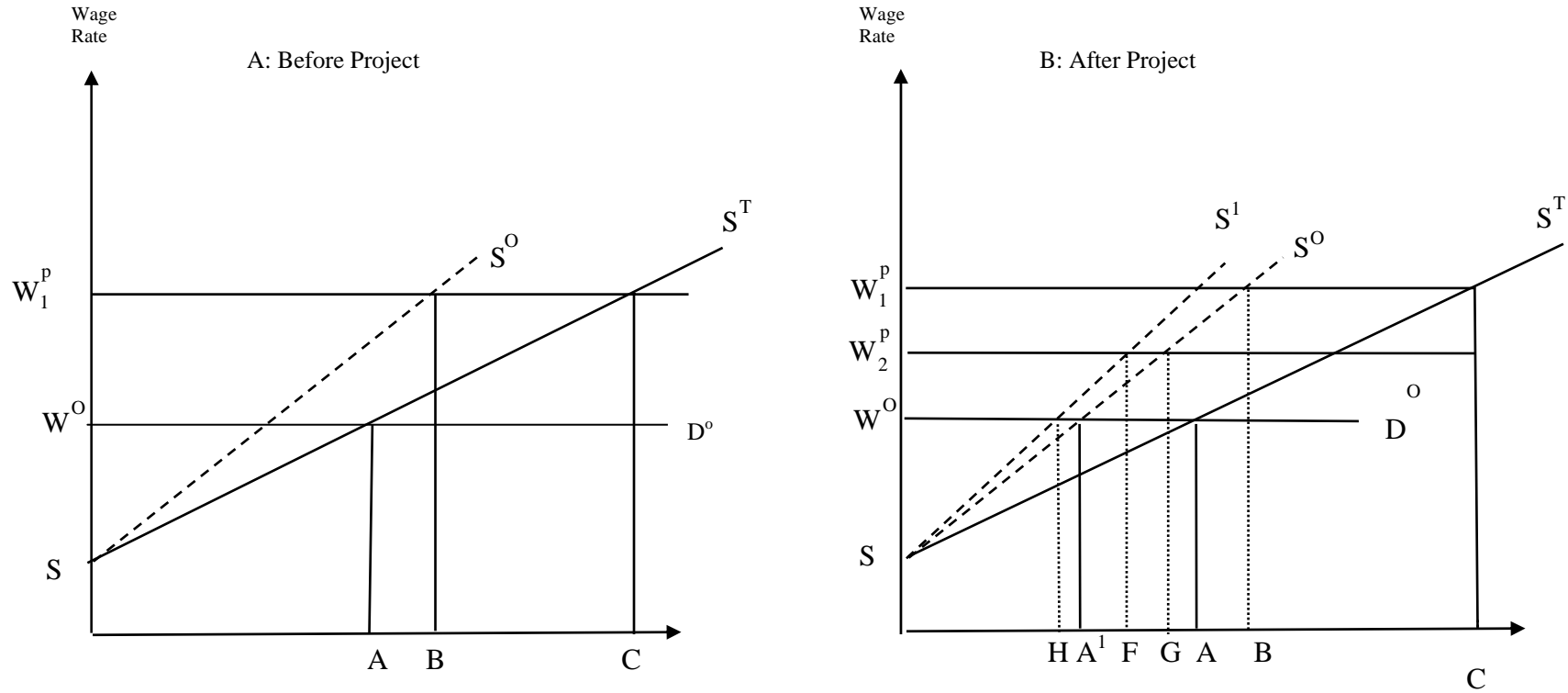
no income taxes. Given the existence of (C-B) jobs in the first protected sector, now a total of G workers would be willing to work in the second protected sector. This is shown in Figure 12.4B, by the intersection of the labor supply curve SS^O and the wage of W_2^P .

The quantities of labor working, respectively, in the first and second protected sectors are given by C-B and G-F. With the introduction of the second protected sector, which hires workers in a random fashion from those willing to work at the wage offered, the quantity of workers employed in the open sector falls from A^1 to H. This contraction comes about because some open sector workers are fortunate enough to be selected for a protected sector job. Similarly, the amount of quasi-voluntarily unemployed falls from $(B-A^1)$ to $(B-G) + (F-H)$. The quantity $(B-G)$ would be willing to work for the protected wage of W_1^P , but none of this group would be willing to work for anything less than W_2^P . Thus, the quantity $(F-H)$ would be willing to work for a wage of W_2^P , but none would work for the open market wage W^O .

In these circumstances the economic opportunity cost of labor in the second protected sector is the weighted average of the open wage (W^O) for those sourced from the open sector, and the average of the open sector wage and the second protected sector wage $(W_2^P + W^O)/2$ for those sourced from the quasi-voluntarily unemployed who are willing to work in this sector. The weights are the shares of the quantity of open sector workers to the total quantity of labor available at a wage of W_2^P (i.e., A^1/G), and the quantity of quasi-voluntarily unemployed to the same total quantity available, (i.e., $(G - A^1)/G$). Hence, the economic opportunity cost of the second protected sector jobs can be expressed as:

$$EOCL_2^P = W^O(A^1/G) + [(W_2^P + W^O)/2] [(G - A^1)/G] \quad (12.11)$$

**Figure 12.4: Estimating the Economic Opportunity Cost Of Labor for Protected Sector Jobs
(Two Protected Sectors and $\eta = \infty$)**



When income taxes are levied on wages in both the protected and open sectors, the same adjustment as made in equation (12.10b) is needed to recognize the loss of income tax revenue from the net reduction in employment in the open sector when protected sector jobs are created. Hence, equation (12.11) becomes:

$$EOCL_2^P = W^O(A^1/G) + [((W_2^P + W^O)/2)(1-T)][(G - A^1)/G] \quad (12.11a)$$

Under the assumptions used in the above example, similar expressions can be derived to measure the economic opportunity of labor for any number of protected sector, each with their own wage rate. If the total supply function of labor to the market is a linear function of the wage rate, (i.e. the quantity of labor supplied at a given wage is $Q_i = S^T\{W_i\}$), then from Figure 12-4B we can define the following relationship:

$$A/C = S^T\{W^O\}/S^T\{W_1^P\} \text{ and } A^1/G = S^O\{W^O\}/S^O\{W_2^P\}$$

As $(C - A)/C = [S^T\{W_1^P\} - S^T\{W^O\}]/S^T\{W_1^P\}$, it follows from the geometric properties of similar triangles and parallel lines that:

$$(G - A^1)/G = [S^O\{W_2^P\} - S^O\{W^O\}]/S^O\{W_2^P\}$$

The economic opportunity cost of labor in the first protected sector can be calculated as follows:

$$EOCL_1^P = W^O [S^T\{W^O\}/S^T\{W_1^P\}] + (W_1^P + W^O)/2 [(S^T\{W_1^P\} - S^T\{W^O\})/S^T\{W_1^P\}] \quad (12.12)$$

Likewise, the economic opportunity cost of labor in the second protected sector can also be expressed as follows:

$$EOCL_2^P = W^O [S^O\{W^O\}/S^O\{W_2^P\}] + [(W_2^P + W^O)/2] [(S^O\{W_2^P\} - S^O\{W^O\})/S^O\{W_2^P\}] \quad (12.13)$$

In general, it follows that under these conditions (i.e. linear supply curve and a perfectly elastic demand for labor at the open wage of W^O), the EOCL for any protected sector paying a wage, W_i^P , can be expressed as:

$$EOCL_i^P = W^O [S^T\{W^O\}/S^T\{W_i^P\}] + [(W_i^P + W^O)/2] [(S^T\{W_i^P\} - S^T\{W^O\})/S^T\{W_i^P\}] \quad (12.14)$$

The economic opportunity cost of labor for any protected sector is simply a weighted average of (a) the open sector wage, W^O , and (b) the average of the specific protected sector wage and the open sector wage. The weights can all be expressed as functions of the original total market supply of labor $S^T\{W_i\}$.

When income taxes are levied on wages in both the protected and open sectors, the same adjustment as made in equation (12.10b) is needed to recognize the loss of income tax revenue from the net reduction in employment in the open sector when protected sector jobs are created. Hence equation (12.15) becomes:

$$EOCL_i^P = (W^O) [S^T\{W^O\}/S^T\{W_i^P\}] + [(W_i^P + W^O)/2] (1-T) [(S^T\{W_i^P\} - S^T\{W^O\})/S^T\{W_i^P\}] \quad (12.15)$$

(iii) *EOCL in the Case of Search Unemployment with No Migration*

This analysis of unemployment assumes that all of the workers, whether employed in the open market or quasi-voluntarily unemployed, have an equal chance of obtaining the protected sector job. However, in practice some workers will have more to gain (by their own assessment) from the protected sector job than others and, therefore, can be expected to go to greater lengths to obtain those positions. A part of this extra effort is likely to be reflected in the form of search unemployment, which is a particular form of voluntary unemployment. Search unemployment can be thought of as a category where the worker voluntarily accepts unemployment with the intention of enhancing the probability of getting a protected sector job.

Figure 12.5A depicts a labor market in which both search unemployment and the standard type of quasi-voluntary unemployment coexist. We also introduce a less than infinite elastic demand for labor in the open sector LD^O . The curve $W^m S^O$ is the supply curve of all those

willing to work in the open market. This supply curve has been adjusted for the effect that searching has on the supply of labor available to the open market. The interaction of the demand function for open market workers LD^o with that supply of open market workers $W^m S^o$ determines the initial open market wage W^o . The lateral distance between this new supply curve, $W^m S^o$, and the prior supply curve, SS^o , is the quantity of search unemployment corresponding to any given open market wage. When the wage is W^m , the number of workers who opt for search unemployment is equal to the distance $W^m E$, whereas it is the difference between F and G at the open market wage W^o . This distance is greatest at the wage W^m . At this wage all those not working for the protected sector would prefer to remain unemployed to search for protected sector jobs instead of accepting jobs in the open market. As the open market wage rises, fewer and fewer workers are willing to forgo open market earnings in order to seek protected sector jobs, until, finally, as the open market wage approaches the protected sector wage, W^p , the quantity of search unemployment approaches zero.

When additional protected jobs are introduced into the protected sector under these conditions, a proportion of the new positions will be filled from each of the three labor pools: search unemployed, quasi-voluntary unemployed and those currently employed in the open sector.¹⁵ The EOCL will be the sum of the supply price times the proportions of the new hires that come from each of those sectors. Workers who opt for search unemployment are voluntarily accepting a gamble, in which one outcome is to be unemployed, and the other is to have a protected sector job. The value of that gamble to them is precisely the open market wage at which they would willingly withdraw from the search process. Therefore the supply price of the search unemployed workers (W^s) will be given by equation (12.16):

$$W^s = P_1 (0) + P_2 (W^p) \quad (12.16)$$

where P_1 denotes the probability of getting zero income, and P_2 denotes the probability of getting a protected sector job. W^s will necessarily be higher than W^o because the open market wage is available with certainty, but these individuals refuse to work at this wage in preference to search for a protected sector job that pays W^p .

¹⁵ To simplify the analysis we are going to ignore the reaction of the open market wage to the decrease in the workers now available to the open market. This analysis is shown in Figure 12.5B

The quasi-voluntary unemployed are unwilling under any circumstances to work at the wage W^o , requiring a higher wage in order to reenter the workforce. Workers sourced from quasi-voluntary unemployment for jobs at the protected sector wage (W^p) will (with linear supply curves) have a supply price averaging $((W^o + W^p)/2)$. Finally, the supply price for workers already employed in the open sector will simply be the open market wage, W^o , because they have already shown a willingness to accept work at that wage rate. Hence, we estimate the economic opportunity cost of labor for the protected sector project by combining those supply prices and the proportions of labor from each sector as follows:

$$EOCL^P = W^S H^S + [(W^o + W^p)/2] H^{QV} + W^o H^O \quad (12.17)$$

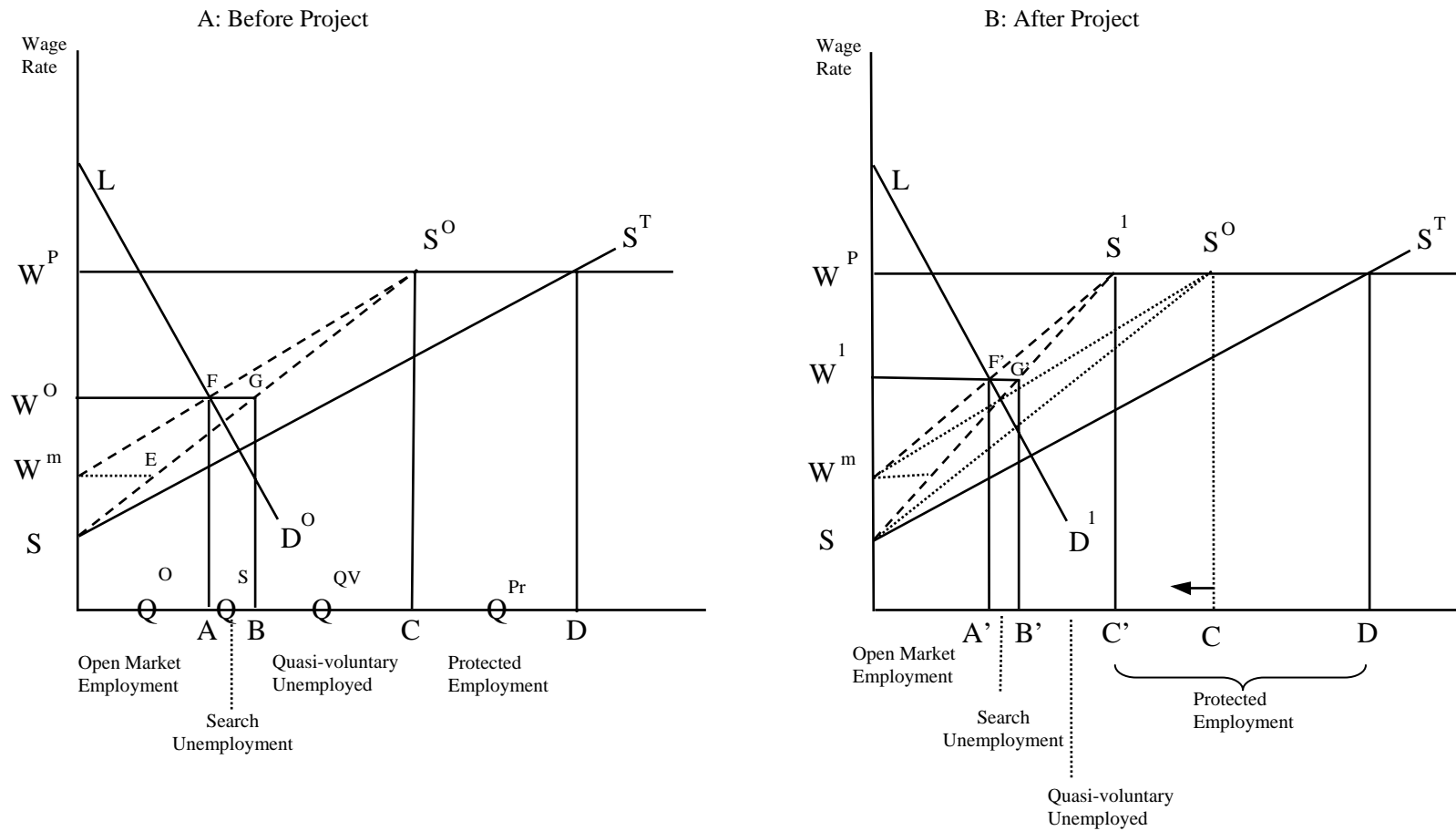
where H^S , H^{QV} , and H^O stand for the proportion of labor sourced from each of search unemployed, quasi-voluntary unemployed and currently employed in the open market sector.

If the people obtain the permanent jobs in a manner unrelated to their supply prices, then:

$$H^S = Q^S / (Q^S + Q^{QV} + Q^O); H^{QV} = Q^{QV} / (Q^S + Q^{QV} + Q^O); H^O = Q^O / (Q^S + Q^{QV} + Q^O)$$

Comparing this value with the EOCL when there is only quasi-voluntary unemployment, the addition of the economic cost of search unemployment ($W^S H^S$) will tend to raise the open sector's wage (W^o) and, hence, raise the economic opportunity cost of labor for the project in the protected sector.

Figure 12.5: Estimating the Economic Opportunity Cost of Labor with Quasi-Voluntary and Search Unemployment



(iv) EOCL if there is no Open Sector and Labor Market Supplied by Migrants

In some circumstances we find that no open sector has been allowed to develop either because of the strict enforcement of minimum wage laws or the nature of the development in the area, (e.g., one company town, or where the only sources of employment available are protected sector jobs). In this case, we want to assume that it is the migration of labor from other regions that is the source of additional workers. Workers will be attracted to the region because the protected sector wage is greater than their supply price of labor for that place. Not all potential workers will find employment, some who come to the area in search of a protected sector job will end up being unemployed.

In this case we must differentiate between the supply price of an additional potential worker (a migrant) and the economic opportunity cost of labor required to fill a job. The potential migrant evaluates her prospects in the region where there are protected sector jobs with the opportunities available around her. If she migrates, there is a probability of finding a protected sector job (P^P), and also a probability $(1-P^P)$ of being unemployed. Hence, from the perspective of a potential migrant, if the protected sector wage is W^P , the expected wage from migrating $E(W)$ is equal to the product of the protected sector wage (W^P) and the probability of being employed in the protected sector (P^P), i.e., $E(W) = P^P W^P$.

When there is no open sector, it is the unemployment rate, $(1-P^P)$ which brings about the equilibrium between the supply price of a migrant and the protected sector wage. Suppose the supply price for a migrant to move to the region where there are protected sector jobs is W^m . As this supply price is less than the protected sector wage of W^P , there is incentive for more migrants to move to seek protected sector employment than there are jobs available. This migration process will continue until the probability of finding a protected sector job falls to the point where:

$$P^P = (W^m / W^P) \text{ and } W^m = E(W) \quad (12.18)$$

At this point the potential migrant's expected wage from moving to the protected sector is just equal to her supply price. It means also that when more protected sector jobs are created, the number of migrants to the region in pursuit of these jobs will always be greater than the number of jobs. Hence, when the full adjustment has taken place, the equilibrium unemployment rate will be maintained and the number in the pool of unemployed labor will be increased.

To estimate the EOCL for protected sector jobs, we need to account for the opportunity cost of all migrants, both employed and unemployed, who were induced to move in pursuit of these new jobs. If the equilibrium unemployment rate is $(1-P^P)$, then for every new protected sector job created there will have to be $1/P^P$ migrants. The economic opportunity cost of each of these migrants is equal to $W^P P^P$ when the labor market is in equilibrium. Hence, the economic opportunity cost of labor to fill a protected sector job is expressed as:

$$EOCL^P = (W^P P^P)(1/P^P) = W^P \quad (12.19)$$

In this case where it is the unemployment rate which is the equilibrating force between the protected sector and the rest of the economy, the $EOCL^P$ is equal to the protected sector wage. There is no net economic externality from the creation of protected sector jobs. The additional unemployment created by those searching for a protected sector job inflicts an economic cost on society equal to the difference between the supply price of a migrant and the protected sector wage. As a consequence, when there is no open sector and no other distortions such as taxes, the economic opportunity cost of labor for protected sector jobs is the protected sector wage.

When there are taxes levied on the protected sector wage, and taxes are levied on the wages paid in the sending region, then the $EOCL^P$ will need to be adjusted to reflect the net change in tax revenues. We denote the gross-of-tax wage rates in the protected sector and in alternative employment as W^P and W^a , respectively. Further, if we express the proportion of

migrants from the sending region who would have been employed in that region as H_a , and T is the tax rate, then the $EOCL^P$ can be expressed as:

$$EOCL^P = W^P (1 - T) + H_a W_a T(1/P) \quad (12.20)$$

In this situation the amount of taxes lost from reduced activities in the sending regions must account for the fact that not all the adjustment comes from reduced employment. Further for every new protected sector job there will be more than one migrant moving to the labor market where the protected sector jobs are located.

12.9 Conclusion

In this chapter the economic opportunity cost of labor has been estimated using the supply price approach under a wide variety of labor market conditions and types of jobs. This approach is shown to be equivalent to the value of the marginal product of labor forgone approach, when the latter can be estimated accurately. The primary reliance of the supply price approach greatly facilitates the estimation of this economic parameter for use in the economic valuation of projects.

A methodology has been outlined in detail to account for several adjustments that may need to be made to this supply price to reflect special labor market characteristics and distortions. Most of these factors, such as income taxes and unemployment insurance compensation, are straightforward and easy to estimate. Others such as those dealing with interregional and international migration, as well as imperfections in the labor market, including phenomena like migration-fed, quasi-voluntary unemployment, and employment created in protected sector jobs require a more detailed examination of the labor market. In all these cases the special features in question give rise to the need for further specific adjustments in the calculation of the economic opportunity cost of labor for a specific skill on a particular project.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 13:**

EVALUATION OF STAKEHOLDER IMPACTS

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ABSTRACT

The stakeholder impacts of a project can be estimated by the comparison of the financial and economic impacts of the project on the key stakeholders of a project. This analysis allows one to estimate how the income changes caused by the project that are distributed across the key groups affected by the project. This analysis allow for a reconciliation of the financial, economic, and distributional aspects of a cost benefit analysis. It also identifies if the project does or does not address the principal social objectives of the society. This chapter covers how the benefits and costs associated with a project are identified and measured for the principal stakeholder groups in a country.

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CHAPTER 13

EVALUATION OF STAKEHOLDER IMPACTS

13.1 Introduction

The social analysis of a project may be organized into two parts. One is to estimate how the income changes caused by the project are distributed. This part includes the reconciliation of financial, economic, and distributional appraisals. It also identifies the impact of the project on the principal objectives of the society. This chapter covers how the benefits and costs associated with a project are distributed among different stakeholder groups.

The distributive analysis of the project asks the following questions: Who will benefit from the project and by how much? Who will pay for the project and how much will they pay? The sustainability of any project is heavily impacted by which parties in the project's sphere of influence gain or lose because of it. If an influential group is expected to bear the burden of losses, then the successful implementation of the project may be hindered. The risk of a strong political opposition to the project mobilized by the losing party is a contingency that the project's implementers should be prepared to tackle.

Another aspect of the social analysis is concerned with cases in which project will facilitate or hinder process of helping society to address its basic needs. For example, a road project may not only reduce transportation cost, but also increase the level of security in a village or allow more children to attend school, both of which are viewed positively by the society. In such cases society may want to credit an extra net benefit (a social externality) to the project. This basic needs externality will be dealt with in Chapter 14.

This chapter begins with a discussion of distributive analysis and the impact of a project on poverty alleviation . It is followed by the description of the methodology for reconciling economic and financial values in different cases. These include a) the case of a major expansion in the supply of a non-traded good in an undistorted market, b) the case of a non-traded good sold to a market with a unit tax, and c) the case of an importable input that is subject to tariff. The next section provides an illustration of integrated financial, economic and distributional analysis from

three cases -- the Poverty Reduction Effects of an Agricultural Development Project, a Workers' Transportation Project and the Jamuna Bridge Project. Concluding remarks are made in the last section.

13.2 Nature of Distributive Analysis

A traditional financial analysis examines the financial feasibility of the project from the owners' and the total investment points of view. Economic analysis evaluates the feasibility from the point of view of the whole country or economy. A positive economic NPV implies a positive change in the wealth of the country, while a positive financial NPV from the point of view of any particular stakeholder group indicates a positive expected change in the wealth of that group's members .

The difference between the financial and economic values of an input or output of a project represents a benefit or a cost that accrues to some party other than the financial sponsors of the project. These differences can be analyzed by undertaking a distributive analysis that allocates these externalities (differences between economic and financial values) to the various parties affected. For example, a project that causes the price of a good to fall will create economic benefits that are greater than its financial revenues. This difference between the financial and the economic values will represent a gain to the consumers of the output and a loss to the other producers of the good or service that are competing in the market with the project. The differences between the financial and economic values of other inputs and outputs may also arise due to a variety of market distortions such as taxes and subsidies, or because the item sold to consumers is at a price different from the marginal economic cost of additional supply.

Tariffs, export taxes, sales and excise taxes, production subsidies and quantitative restrictions create common market externalities. Public goods are normally provided at prices different from their marginal economic costs. The economic values of common public services such as clean water and electricity are the maximum amounts people are willing to pay for these services. These values are often significantly greater than the financial prices people are required to pay for the services. Any of these factors will create divergences between the financial and the economic prices of goods and services consumed or produced by a project.

A distributive analysis is composed of six distinct steps:

- Identify the externalities;
- Measure the net impact of the externalities in each market as the real economic values of resource flows less the real financial values of resource flows;
- Measure the values of the various externalities throughout the life of the project and calculate their present values using the economic opportunity cost of capital;
- Allocate the externalities across the various stakeholders of the project;
- Summarize the distribution of the project's externalities and net benefits according to the key stakeholders in society; and
- Reconcile the economic and financial resource flow statements with the distributional impacts.

In essence, a distributive analysis seeks to allocate the net benefits/losses generated by a project. As a result, this analysis is important to decision makers as it lets them estimate the impact of particular projects on segments of society, and to predict which groups will be net beneficiaries and which groups will be net losers.

For example, a project is especially designed to address poverty alleviation.¹ When the project reduces the price of a good or service, the demanders of the output can acquire the good at a lower price. The net benefit will be identified and quantified in the distributive analysis. If the poor are the demanders, this project will have a poverty alleviation impact. In the case of water, the willingness to pay by the poor to water vendors is often fairly high due to the necessity of water. Often the poorer with limited access to water are paying more for marginal supplies of water than are the better off demanders. Thus, a new project that increases the supply of potable water may end up providing it at a lower price for everyone. But the benefit brought by this lower price may be deemed to be greater to the degree that it accrues to the poorer strata of the society, thus contributing to poverty alleviation. To be able to quantify this impact one needs to evaluate the differences between the economic value and financial cost of the water being demanded by the various income groups.

¹ This issue has been identified as a major reason for development assistance by the World Bank. See Wolfensohn, J. D., "The Challenge of Inclusion", presidential address to the Board of Governors, Hong Kong, China, (September 23, 1997).

Another channel for a project to have an impact on the incidence of poverty is through the labor market. When the lower income groups sell their services to projects that pay a wage rate significantly above the workers' supply prices for their labor, they are likely to be made better off by the project. The differences between the supply price of labor and the financial wage paid by the project will be measured as an externality and that can be allocated according to the various income groups to determine whether the project has a direct impact on poverty alleviation.

13.3 Reconciliation of Economic and Financial Values of Project Inputs and Outputs

When the economic and the corresponding financial values of variables are expressed in terms of the same numeraire, we wish to show for each variable that the economic value can be expressed as the sum of its financial value plus the sum of the externalities which cause the financial and economic value to differ.² These externalities may be reflecting things such as taxes, subsidies, changes in consumer and producer surplus or public good externalities.

If each of the variables are discounted using any common discount rate (in this case the economic opportunity cost of capital), it must be the case that the NPV of the economic net benefits are equal to the NPV of the financial net cash flows plus the present value of the externalities. This relationship can be expressed as in equation (13.1):

$$NPV^e = NPV^f + \sum PV(EXT_i) \quad (13.1)$$

where NPV^e is the net present value of the economic net benefits, NPV^f is the net present value of the financial net cash flows, and $\sum PV(EXT_i)$ is the sum of the present value of all the externalities generated by the project; all discounted using the same economic opportunity cost of capital.

To indicate how this relationship holds for non-tradable and tradable goods, the following situations are considered.

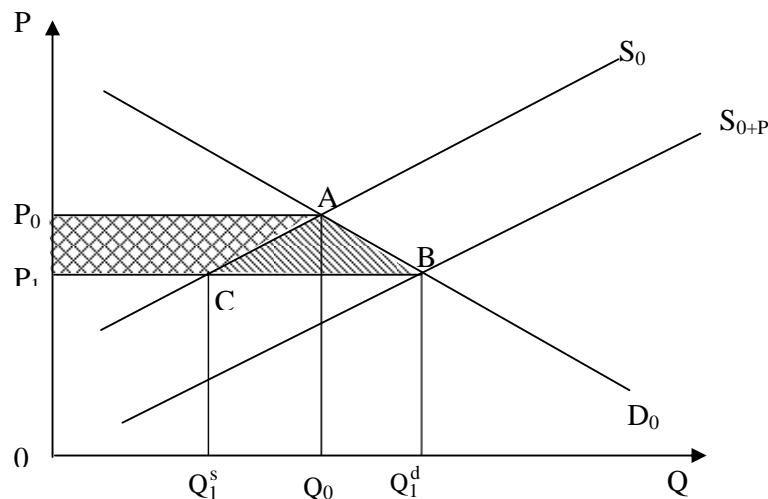
² Details for various cases can be found in Harberger, A. C., "Reflections on Social Project Evaluation" in *Pioneers in Development*, Vol. II, edited by G. M. Meier, Washington; The World Bank and Oxford: Oxford University Press, (1987).

13.3.1 The Case of an Expansion in the Supply of a Non-Tradable Good in an Undistorted Market

In Figure 13.1 we illustrate the market of a good that is the output of a project. The project results in an increase in the supply of a non-tradable good in a market with no tax or subsidy distortions. One example would be a project that increases the supply of drinking water at a lower cost, hence expanding total consumption while also reducing the quantity generated by higher cost plants.

Before the project was introduced, the equilibrium price and quantity were P_0 and Q_0 , respectively. P_0 represents the price paid for drinking water prior to the project. Introducing the project causes the supply curve to shift to the right. Price falls to P_1 , which is the price of drinking water after the project; total demand increases to Q_1^d , and the quantity supplied by others is reduced to Q_1^s . The financial value of the output is $Q_1^s CB Q_1^d$ and the economic value is $Q_1^s CAB Q_1^d$. The difference between the economic and the financial values is CAB , which is the sum of two distributional impacts: the demanders' gain, P_0ABP_1 and other producers' loss, P_0ACP_1 .

Figure 13.1: Financial and Economic Values for Production of a Non -Tradable Good



In summary, when there are no distortions in a market, the gross value of a non-tradable good or service from a project which causes a change of the price of the good or service can be decomposed into:

$$\begin{aligned} \text{Economic Value of the output} &= \text{Financial Value of the Output} \\ &+ \text{Gain in Consumer Surplus} \\ &- \text{Loss in Producer Surplus} \end{aligned}$$

While the example assumes that there is a market determined price before and after the project, this could just as easily be an illustration of public services such as a road, before and after it has undergone a major improvement. In such a case, P_0 would reflect the time and operation costs (per vehicle-mile) before the project, and P_1 would be the sum of these costs per vehicle-mile after the project.

13.3.2 The Case of Non-Tradable Good Sold into a Market with a Unit Tax³

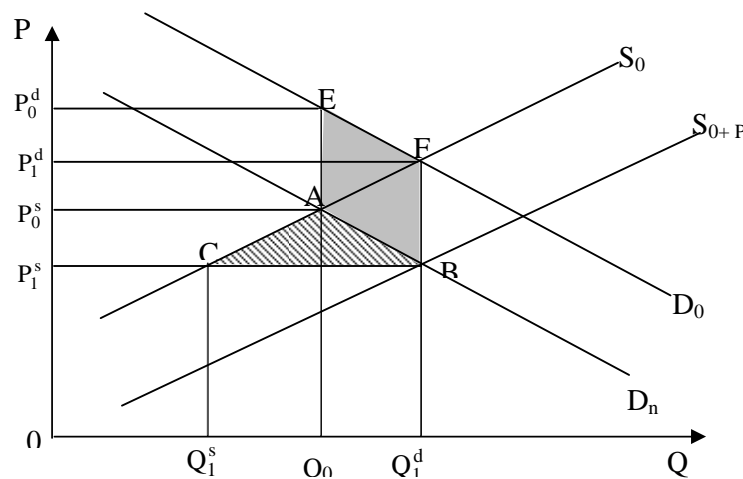
We will now introduce a distortion into the market. Figure 13.2 demonstrates the case of non-tradable good with a unit tax. As the result of a unit tax, the demand curve facing the producer will shift downward to D_n . Before we introduce our project to the market, we have an equilibrium quantity of Q_0 , a supply price of P_0^s , and a demand price of P_0^d , which is equal to the supply price plus the unit tax. After we introduce the project, the quantity demanded increases to Q_1^d , quantity supplied by producers other than the project falls to Q_1^s , the supply and demand prices fall to P_1^s and P_1^d , respectively. The financial value of the output is shown as $Q_1^s CB Q_1^d$. The economic value is shown as $Q_1^s CA Q_0$, the value of resources saved through the contraction or postponement of supply by others, in addition to $Q_0 AB Q_1^d$ plus AEFB, the value to consumers of the increase in the quantity demanded.

The difference between the economic and financial appraisal of the project's output in this case is equal to CAB plus AEFB. Here again, CAB represents the gain in consumer surplus, $P_1^d P_0^d EF$, minus the loss in producer surplus, $P_1^s P_0^s AC$. This is easy to see in the case of a unit tax because $(P_0^s - P_1^s)$ must equal $(P_0^d - P_1^d)$. Hence, the area $P_1^d P_0^d EF$ must equal $P_1^s P_0^s AB$.

³ The illustration in this case is for a unit tax, but the same results also hold for an ad valorem tax imposed on

The area AEFB is equal to $T(Q_1^d - Q_0)$ where T stands for a unit tax or the net gain in government revenue that results from the increased demand. The gross economic value of the output is therefore equal to the financial value ($Q_1^s CB Q_1^d$) plus the change in government tax revenues (EFBA) plus the increase in the consumer surplus ($P_0^d EF P_1^d$ or $P_0^s AB P_1^s$) minus the loss in producer surplus ($P_0^s AC P_1^s$). Consumers gain as a result of the lower price of the good. Producers lose because of the fall in price and reduced production; and the government collects more tax revenues because of the expansion in the quantity demanded due to the lower price.

Figure 13.2: Financial and Economic Values for Production of Non-Tradable Good with a Unit Tax



In summary, when the market is distorted only by a unit tax, the gross economic value of the output of a project can be expressed as:

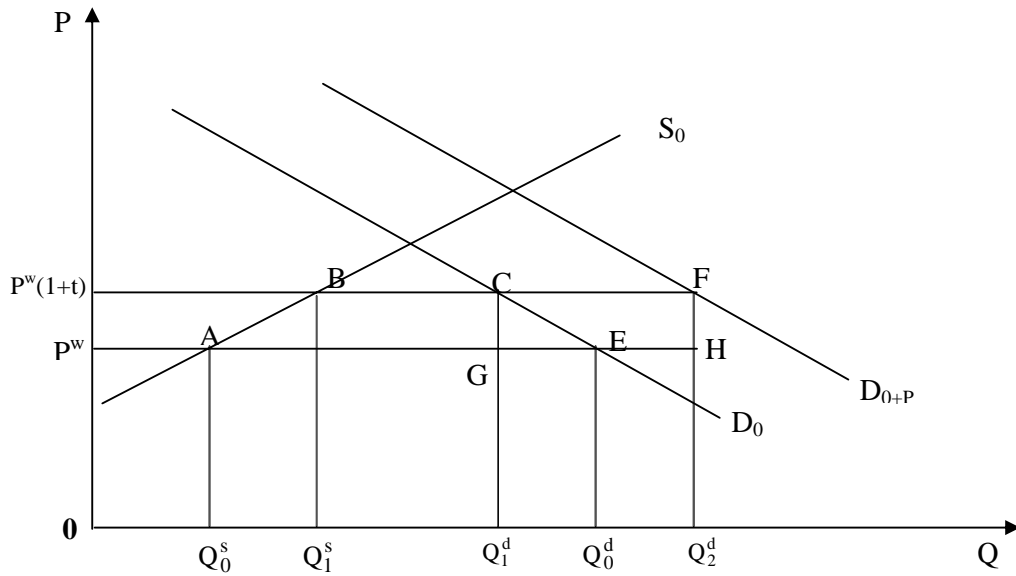
$$\begin{aligned}
 \text{Economic Value of Output} &= \text{Financial Value of Output} \\
 &+ \text{Change in Government Tax Revenues} \\
 &+ \text{Increases in Consumer Surplus} \\
 &- \text{Loss in Producer Surplus}
 \end{aligned}$$

13.3.3 The Case of an Importable Input that is Subject to Tariff

goods or services.

In Figure 13.3, the case of an importable good is illustrated where the inputs of the item are subject to a tariff at a rate of t . The cif price is P^w and the domestic price is $P^w(1+t)$. The initial market equilibrium is found at the domestic price of $P^w(1+t)$ where the quantity demanded is Q_1^d and the quantity supplied by domestic producers is Q_1^s . The quantity imported is $(Q_1^d - Q_1^s)$. A new project now demands an additional quantity of this item as input. This addition to demand is shown as a shift in the market demand curve from D_0 to D_{0+P} .

Figure 13.3: Measuring the Financial and Economic Values of Inputs with Tariffs



Because it is an importable good, this increase in demand will lead to an equal increase in the quantity of the item imported of $(Q_2^d - Q_1^d)$. The financial cost of the additional imports is $P^w(1+t)(Q_2^d - Q_1^d)$, while the economic cost is equal to $P^w(Q_2^d - Q_1^d)(E^e/E^m)$; where E^e is the economic exchange rate and E^m is the financial market exchange rate.

The difference between the economic and financial costs of the importable good can be expressed as $[(E^e/E^m) - 1]P^w(Q_2^d - Q_1^d) - tP^w(Q_2^d - Q_1^d)$. The first term of this expression is the rate of foreign exchange premium $[(E^e/E^m) - 1]$ times the cost of the inputs purchased at world prices P^w . This measures the externality, usually tariff and other tax revenues foregone, from the use of foreign

exchange to purchase the input. Tariff and taxes would have been paid if the foreign exchange required for this purchase had been used to purchase other imports. The second expression is the tariff revenues paid by the project when it imports these inputs.

The net distributional impact on the government is the difference between the two effects. The government gains revenue as a result of the imposition of the tariff on the imported good in question, while it loses because the foreign exchange would otherwise have yielded some tariff revenues elsewhere. These losses are captured by the foreign exchange premium $[(E^e / E^m) - 1]$.

In summary, for the case of an importable good subject to a tariff, the economic cost of the item can be expressed as follows:

Economic cost of importable input = Financial cost

- gain to the government from the tariff revenues paid on the purchase of the item
- + loss in government revenues due to the foreign exchange premium on the foreign exchange used to purchase this input.

13.4 Case Illustrations of Integrated Financial, Economic and Distributional Analysis

If each of the values for the input and output variables that make up a project are broken down into their economic, financial and distributional components, then the end result can be expressed as in equation (13.1) where the economic NPV is equal to the NPV of the financial outcome of the project, plus the present value of a series of distributional impacts on the various stakeholders of the project. Three projects are used below to illustrate the use of a distributional analysis in the determination of the ultimate outcome of the project.

The following three cases illustrate how the estimation of stakeholder impacts is carried out. The output of an integrated analysis identifies the key stakeholders to determine whether the project promoters are likely to face difficulties in project implementation, whether the authorities are likely to be pressured to accept a bad project, or whether the project is likely to face risks to its future sustainability. The answers to the questions of, “who are the stakeholders, and how are

they affected?” are project specific. However, the economic analysis of what affects the economic values of inputs and outputs will provide the basic data for estimating the specific stakeholder impacts. In each of the cases, we have presented the financial cash flow table, the economic resource flow table and the table of externalities for illustrative purposes.

13.4.1 Case A: Workers’ Transportation Project

Suppose a public enterprise is considering the purchase of a bus to transport its low wage workers to and from work. The enterprise is located far away from the residential areas and, as a result, is having difficulty recruiting workers.

Basic Facts about Workers’ Transportation Project

The main features of the project are summarized below:

- Factory currently employs 20 workers.
- Workers currently use taxis at a cost of \$1.00 per trip, i.e., each way, to and from the factory.
- Factory wants to employ 40 workers, but can not recruit any additional worker without either subsidizing transportation or paying higher wages.
- In order to attract the additional 20 workers the enterprise wants to employ, it will either have to pay the workers more or provide a bus which would only charge the workers \$0.40 per trip.
- The proposal is to import a bus at a cost of \$50,000. This price consists of the cif price of \$40,000 plus a tariff of 25%. The bus is expected to have a residual “in use” value of \$20,000 in year 5.
- The bus will operate for 250 days per year.
- It will be necessary to employ a driver to operate and maintain the bus at a wage of \$20 per day. No taxes would be paid by the driver, but it is estimated that the economic opportunity cost of employing the driver is equal to approximately 80% of his wage.
- The cost of oil and gas will be \$4.00 per day. The conversion factor for oil and gas is estimated to be 0.60 because of the high taxes imposed on their purchase price.
- The spare parts bill is expected to be \$200 per year. Tariff and taxes on spare parts are equal to 25 percent of their cif price. The spare parts conversion factor is thus equal to 0.80.

- The ratio of the economic exchange rate to the market exchange rate is equal to 1.
- No income taxes are levied on the income of this public enterprise.
- The financial cost of capital to the public enterprise is 6%, and the economic opportunity cost of capital is equal to 10%.

Project Outcome

A financial, economic, and distributive appraisal of the project is conducted to determine whether the project is feasible financially and economically, and who would gain from the investment. The first step is the financial appraisal in which the financial cash flow from the total investment point of view is compiled in Table 13.1. The company will obtain receipts of \$8,000 per year as a result of running the bus service. This number is obtained by multiplying the price to be charged (\$0.40) times the number of workers that will be transported per day (40) times the number of trips per day (2) times the days of operation per year (250). The final in-use value of the bus (\$20,000) is given in the problem. The cash inflow over the 5-year period consists of the annual receipts plus the final in-use value of the bus.

The financial cost of the bus is equal to the \$40,000 cif price plus the \$10,000 tariff charge. The cost of employing the worker to operate and maintain the bus is \$20 dollars per day. Multiplying this sum by the 250 days of operation per year gives us \$5,000 as the annual cost of operating labor. Fuel costs are obtained by multiplying the \$4 per day charge by the 250 days to get \$1,000 per year. The \$200 annual cost of spare parts was given in the problem. Adding up these items gives us the cash outflow for each of the five years. We obtain the net cash flow by subtracting the cash outflow from the cash inflow.

We obtain the present value of inflows, outflows, and net cash flows by discounting the respective items. When we do the distributive analysis we will need the NPV of the project at both the financial and economic discount rates. Therefore we calculate both those amounts as part of the financial appraisal. The financial NPV at the financial discount rate of 6 percent is -\$27,018 and the financial NPV at the economic discount rate of 10 percent is -\$30,076. Note that the financial NPV at the economic discount rate is a bigger negative number because the economic discount rate is higher than the financial discount rate.

**Table 13.1 Financial Cash Flow for Worker Transportation Project
(dollars in Year 0)**

	NPV@10%	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Cash Inflow							
Receipts	33,359	8,000	8,000	8,000	8,000	8,000	
Final in-Use Value	12,418						20,000
Total Cash Inflow	45,777	8,000	8,000	8,000	8,000	8,000	20,000
Cash Outflow							
Capital Expenditures							
- Bus Purchase	40,000	40,000					
- Tariff on Bus	10,000	10,000					
Operating Expenses							
- Labor	20,849	5,000	5,000	5,000	5,000	5,000	
- Fuel	4,170	1,000	1,000	1,000	1,000	1,000	
- Spare Parts	834	200	200	200	200	200	
Total Cash Outflow	75,853	56,200	6,200	6,200	6,200	6,200	
Net Cash Inflow	-30,076	-48,200	1,800	1,800	1,800	1,800	20,000
NPV Financial @6%	-27,018						

The second step in the analysis is the economic appraisal, represented by the economic resource statement as shown in Table 13.2. The economic value to the workers of the bus service is a combination of the economic benefit to previous workers plus the economic benefit to new workers. The 20 previous workers were willing to pay \$1.00 for a one-way trip. Therefore, their economic benefit from the bus service is the same as previously. We obtain this amount by multiplying the price (\$1.00) times the number of trips per day (2) times the number of previous workers (20) times the number of working days per year (250) for a total of \$10,000.⁴ The value of the bus trip to the new workers varies. Some on the margin would have taken the trip if the price charged had been \$0.99, while the last person would not have taken the trip at a price of \$0.41. In order to take all the new workers into consideration, we take a weighted average of their valuations to find the average price that these new workers would have been willing to pay. Assuming a linear (rectangular) distribution of demand prices of these new workers, this amount comes to \$0.70 per trip (= (\$1.00 + \$0.40)/2). Therefore, the benefit to the additional workers of the bus service is equal to the price of \$0.70 times the 2 daily trips times the 20 workers times the

⁴ Previous workers' benefit is a cash saving of \$0.60 per trip per individual, and hence a total saving for all workers is \$6,000 per year.

250 days of operation, which gives a total of \$7,000.⁵ Adding up the economic benefit to previous workers (\$10,000) and the economic benefit to additional workers (\$7,000) gives us \$17,000 as the gross economic benefit the bus service.

⁵ Consumer surplus to new workers is equal to the amount of \$7,000 in excess of \$4,000, i.e., \$3,000 per year.

**Table 13.2 Economic Resource Statement for Worker Transportation Case
(dollars in Year 0)**

	CF	PV@10%	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Economic Benefits								
Receipts	2.125	70,887	17,000	17,000	17,000	17,000	17,000	
Final in-Use Value	0.8	9,935	0	0	0	0	0	16,000
Total Benefits	-	80,822	17,000	17,000	17,000	17,000	17,000	16,000
Economic Costs								
Capital Expenditures								
- Bus Purchase	1.0	40,000	40,000					
- Tariff on Bus	0	0	0					
Operating Expenses								
- Labor	0.8	16,679	4,000	4,000	4,000	4,000	4,000	0
- Fuel	0.6	2,502	600	600	600	600	600	0
- Spare Parts	0.8	667	160	160	160	160	160	0
Total Costs	-	59,848	44,760	4,760	4,760	4,760	4,760	0
Net Economic Benefits	-	20,974	-27,760	12,240	12,240	12,240	12,240	16,000

Note: Note: CF stands for conversion factor.

The residual value of the bus in economic terms is \$16,000. This is because the tariff has to be allocated to the entire life of the bus. Therefore, the residual tariff value of \$4,000 has to be subtracted from the financial final in-use value of the bus of \$20,000.⁶ By the same token, the cif price of the bus (\$40,000) is the same from the financial and economic points of view. The tariff paid on the bus is only a transfer of income from the enterprise to the government and it is thus not included in the economic appraisal.

We were told that the economic value of labor is 80 percent of its financial value. This means that labor has a shadow price that is 80 percent of its private opportunity cost. Therefore, the economic value of labor is equal \$4,000 per year. Fuel has a conversion factor of 0.6, so the economic price of the fuel is equal to \$600. The difference between the financial and economic

⁶ A conversion factor of 0.8 was used to calculate the final economic in-use value of the bus. We calculated this conversion factor by dividing the economic value of the bus by its financial value (i.e., the CF = 40,000/50,000). Since the difference between the financial and economic is \$4,000, we know that this is the residual tariff value.

prices of fuel is due to taxes that were paid on the purchase of fuel. These taxes are a transfer within the economy and are therefore not accounted for in the economic appraisal. The 0.8 conversion factor for spare parts is multiplied by the financial value (\$200) to give the economic value of \$160. Here again, the difference between financial and economic values can be attributed to taxes paid.

Subtracting the economic costs from the economic benefits yields the economic net benefits. Discounting these values using the economic cost of capital gives us \$20,974 as the present value of net economic benefits.

The final step is an appraisal of the distributional effects of the project as presented in Table 13.3. The distributive appraisal looks at net transfers in the economy as a result of the project. We want to determine how the net benefits from having the bus service are distributed among the various participants. In this case, the relevant impacts are on the government, the consumers (i.e., the workers who will use the service to get to work), and the labor that will be hired to operate the bus. We first calculate the present value of net benefits to consumers, which is the same as saying that we are calculating the change in consumer surplus. Remember that the formula we developed earlier requires us to obtain the present value of externalities at the economic discount rate. To calculate the present value of this benefit, we have to subtract the financial receipts (\$8,000) from the economic receipts (\$17,000) for each of the five years, which comes to \$9,000 per year. Discounting this cash flow stream using the economic cost of capital gives us a present value of \$37,528. This positive externality goes to bus riders.

The transfer to the government of tariff revenue from the bus purchase is \$10,000 in year 0. In year 5, however, the project effectively releases the bus back into the economy and recaptures \$20,000, but the economy only values the bus at \$16,000. This increase in the supply of buses in the economy causes a loss of tariff revenue to the government that has a present value of -\$2,484. Therefore, the net tariff revenue received by the government is calculated by subtracting the loss in tariff revenues in year 5 of \$2,484 from the \$10,000 received in year 0.

Table 13.3
Allocation of Net Benefits for Worker Transportation Project
(dollars in Year 0)

	Externalities	Government	Workers	Driver
Benefits				
Receipts	37,528		37,528	
Final in-Use Values	-2,484	-2,484		
Total Benefits	345,044			
Costs				
Expenditures				
-- Bus Purchase				
-- Tariff on Bus	10,000	10,000		
Operating Expenses				
-- Driver	4,170			4,170
-- Fuel	1,668	1,668		
-- Spare Parts	167	167		
Total Costs	16,004			
Net Resource Flows	51,050	9,351	37,528	4,170

The transfer to labor (the bus driver) is calculated in the same way as the calculation of the present value of net benefits to consumers. We subtract the economic wage received (\$4,000) from the financial wage (\$5,000) for each of the five years. Discounting this cash flow at the 10 percent economic discount rate gives us a present value of \$4,170. This is a positive transfer to labor since it was included in the financial costs, but not in the economic costs.

There is also a transfer to the government as a result of taxes paid on the purchase of fuel and spare parts. In both these cases, the economic costs are lower than the financial. The difference between the financial and economic costs of fuel is \$400 per year. The present value of this stream is equal to \$1,668. The difference for spare parts is \$40 per year. This cash flow stream has a present value of \$167.

To determine the overall distributive impact of the project, we need to calculate the net effects on each of the affected groups. Adding up the impacts on the government, we see that it gains \$9,352 as a result of the project. The workers who will use the bus gain \$37,528 and the labor hired to operate the bus gains \$4,170. The sum of these externalities is equal to \$51,050.

Reconciliation of the Project

Using equation (13.1), we can summarize the previous tables as follows:

$$NPV^e = NPV^f + \sum PV(EXT_i)$$

$$20,974 = -30,076 + 51,050$$

From the point of view of the bus company, this is a bad project, but it looks good economically. The decision about whether or not to go on with a project where the financial and economic appraisals give such different results will depend on whether there are ways to make the project attractive. It may be that the value of the marginal product of the additional workers is sufficiently greater than the wage they are paid to make it attractive to the factory owner to underwrite the financial losses of the bus. Alternatively, the government may levy taxes on the whole community to subsidize the operation of this bus because of the distributional benefits the workers will receive who now obtain this service.

13.4.2 Case B: Tomato Paste Production Project

This is a project undertaken in the Philippines which appears to be attractive based on the results of the integrated financial and economic analysis. The plant was built in a rural area that has a suitable climate for growing tomatoes. Cooperative of small farmers was organized to grow the tomatoes under contract with the processing plant. The financial and economic analysis shows that the economic NPV of the project was much higher than its financial NPV. The stakeholder analysis indicated that the government, the farmers and the domestic consumers will be the main beneficiaries of this project.

Basic Facts about Tomato Paste Production Project

The main features are summarized below:

- The Tomato Paste project has an economic life of 15 years. The project would be able to produce 20,200 tons of tomato paste per year. Under a contractual arrangement with the plant, 3,000 farmers would be organized into cooperatives for the supply of fresh tomatoes to the plant, which would reach about 109,000 tons at the peak of the plant's production.
- The project mainly targeted the domestic market. The demand for tomato paste was projected to grow at a rate of 7.7% during the next coming 10 years. Part of the project's outputs would be exported. Exports are expected to vary from 46 to 20% of the total sales from 2003 to 2010 and progressively decline to a level of about 3.5% of the total production in later years as domestic consumption increases.

- At the production output level of 20,200 tons per year, the project would cause the tomato paste to shift from the import to the export category. This in turn would cause its internal price to be determined by its fob price instead of its cif import price plus tariff and transport costs.
- The project cost was estimated at US\$ 22 million with a foreign exchange component of US\$9.2 million.
- The project's main items of expenditure are raw tomatoes, direct labor, energy, processing overhead cost, packaging materials, selling and administrative expenses and maintenance, and staff costs. The project staff consists of 370 permanent staff and temporary staff employed during the high season. Payroll costs are the most significant component of the project's operating costs.
- The Tomato Paste Plant would enjoy a 6 year tax holiday and then would be subject to income taxation.
- The financial real cost of capital was estimated to be 10%.
- The economic benefits of the project's output fall into four categories:
 - The economic benefits of the quantity exported which includes:
 - The fob value of the exports, plus
 - The foreign exchange premium on the fob value, minus
 - The transportation costs from the factory to the port.
 - The benefits of additional consumption by the new domestic consumers.
 - The benefits of the reduction in the quantity imported, which is the benefit of import substitution. Its economic value equals the cif value of the previously imported quantity, plus the foreign exchange premium, minus the transportation costs from the factory to the port.
 - The benefits of the cutback in production by other producers, which is the savings in production inputs or resource savings for the economy.
- The market exchange rate was 45 pesos per U.S. dollar.
- The foreign exchange premium was assumed to be 6% of the financial cost of foreign exchange.
- The economic opportunity cost of capital was assumed to be 11% real.

Project Outcome

Tables 13.4, 13.5, and 13.6 summarize the financial, economic, and distributive analysis of this project. The economic outcome of the project is reconciled with the financial outcome and the expected distributional impact. All values in these tables are expressed in real pesos.

Table 13.4
Financial Cash Flow for the Tomato Paste Production Project
(millions of Pesos in 2000 prices)

Category	2000	2001	2002	2003	..2007	...201	...201
Revenue							
Net sales							
- Domestic			74.4	92.00	158.0	189.8	16.44
- Exports			0	84.6	41.14	7.76	0
Change in accounts receivable			-6.20	-8.97	-1.20	-1.20	15.25
Leasing receipts			4.85	4.85	0	0	0
Salvage value							6.27
Total Cash Inflow			73.1	172.4	198	196.4	37.96
Investment Cost							
- Project cost	145.55	80.2					
- Initial working capital							
-- Cash balance		6.5					
-- Advances to farmers		58.4					
Operating Costs							
- Raw tomato			28.5	78.95	85.6	85.6	
- Direct labor			0.35	1	1.15	1.25	
- Energy			4.6	12.75	13.8	13.8	
- Processing overhead costs			0.9	2.5	2.7	2.7	
- Packaging materials			6.25	18.35	10.5	4.85	
- Selling and administrative expenses			13.5	16.45	16.45	16.45	
- Change in accounts payable			-2.45	-4.55	-0.4	-0.5	6
- Change in cash held as working capital			1.05	10	0.95	1.15	-14.45
- Change in advances to farmers							-17.05
- Corporate Income Tax						25.2	2.85
Total Cash Outflow	145.55	145.05	52.7	135.4	130.7	150.5	-22.64
Net Cash Flow	-	-	20.3	37.05	67.26	45.87	60.6
NPV Financial @ 10%	74.6						
NPV Financial @ 11%	52.1						

From Table 13.4 we find that the financial NPV discounted at a 10% rate is 74.6 million pesos. The cash flow after the project is built is projected to be positive in 2002 and continuously

positive through the end of the project in 2017. All cash flow values presented in the above table are expressed in real prices at the price level of 2000.

We can see from Table 13.5 that the economic appraisal of the project indicates that project is good for the country. The NPV of the economic benefits is 372.37 million pesos discounted at a real economic cost of capital of 11%. From an economic point of view, this project is expected to contribute positively to the overall welfare of the economy.

Table 13.5
Economic Resource Statement for the Tomato Paste Production Project
(millions of Pesos in 2000 prices)

	CF	2000	2001	2002	2003	..2007	...201	...201
Economic Benefits								
Net sales								
- Domestic	0.884			65.8				
- Domestic and Exports	1.081				190.8	215.3	213.6	17.76
Change in account receivable	1.081			-6.70	-9.69	-1.28	-1.31	16.5
Leasing receipts	1.000			4.85	4.85			
Salvage value	1.112							6.45
Total Economic Benefits				63.9	186.0	214.0	212.3	40.71
Investment Cost								
- Project cost	1.029	149	82.5					
- Initial working capital								
-- Cash balance	1.000		6.5					
-- Advances to farmers	1.000		58.4					
Operating Costs				42.6	106.6	100.0	95.68	-27.10
- Raw tomato	0.651			18.5	51.36	55.7	55.7	
- Direct labor	1.000			0.35	1	1.15	1.25	
- Energy	1.070			4.92	13.63	14.78	14.78	
- Processing overhead costs	1.009			0.9	2.5	2.7	2.7	
- Packaging materials	0.817			5.11	14.98	8.56	3.95	
- Selling and administrative expenses	1.000			13.5	16.45	16.45	16.45	
- Change in accounts payable	0.727			-1.7	-3.30	-0.29	-0.35	4.37
- Change in cash held as working	1.000			1.05	10	0.95	1.15	-14.45
- Change in advances to farmers	1.000							-17.05
- Corporate Tax								
Total Economic Costs		149.	147.38	42.6	106.6	100.0	95.68	-27.10
Net Economic Benefits		-149.	-147.4	21.3	79.4	114.0	116.6	67.18
NPV Economic @ 11%		372.3						

Note: CF stands for conversion factor.

Allocation of Externalities among Stakeholders

Table 13.6 shows the distributional impacts of this project. The values in this table are calculated with taking the differences of the economic values from their financial values. These differences are obtained by subtracting the present value of the rows in Table 13.4 (Financial Appraisal from Total Investment Point of View) from the corresponding present values of the rows in Table 13.5 (Economic Appraisal) and decomposing the differences into the various distributional impacts (among the main stakeholders). The NPV discounted at the economic cost of capital of the externalities generated by the project is 320.23 million pesos.

Table 13.6
Allocation of Net Benefits for the Tomato Paste Production Project
(millions of Pesos in 2000 prices)

Category	Sum of Total Externalities	Govt.	Farmers	Consumers	Existing producers
Benefits					
Net sales					
- Domestic in year 2002	-6.99	-6.99			
- Domestic and Exports (2003-2017)	90.08	51.21		56.01	-17.14
Change in accounts receivable	-1.31	-1.31			
Leasing receipts					
Salvage value	0.03	0.03			
Total	81.81	42.94		56.01	-17.14
Investment Cost					
- Project cost	6.36	-6.36			
- Initial working capital					
-- Cash balance					
-- Advances to farmers					
Operating Costs					
- Raw tomato input	-175.87		175.87		
- Direct labor					
- Energy	5.68	-5.68			
- Processing overhead costs	0.14	-0.14			
- Packaging materials	-11.78	11.78			
- Selling and administrative expenses					
- Change in accounts payable	1.82	-1.82			
- Change in cash held as working capital					
- Change in advances to farmers					
- Corporate Income Tax	-64.78	64.78			
Total	-238.42	62.54	175.87		
Stakeholder Impacts	320.23	105.48	175.87	56.00	-17.14

Reconciliation of the Project

Using equation (13.1), we can summarize the tables as follows:

$$NPV^e = NPV^f + \sum PV(EXT_i)$$

$$372.37 = 52.14 + (105.48 + 175.87 + 56.00 - 17.14)$$

where NPV^f is obtained from Table 13.4 but discounted at the economic opportunity cost of capital.

Distribution of Net Benefits is summarized as follows:

- The farmers will realize an additional income of 175.87 million pesos which is the result of the difference between the price farmers actually receive and the economic cost of production. This higher income will be earned by the farmers from the prices they will receive for supplying fresh tomatoes to the project.
- The existing tomato paste producers will lose part of the market as a result of decrease in the tomato paste price in the domestic market. When the project starts selling tomato paste, it lowers the price of tomato paste. The fall in the price will create a negative externality on existing producers by making them worse off. Therefore, the existing producers of tomato paste will lose 17.14 million pesos that they were going to earn from their production before the new project enters in to the market.
- Consumers of tomato paste would realize a positive externality of 56.0 million pesos. This positive net benefits will be generated through the reduction in the price of tomato paste, and hence an increase in the consumption by the consumers. This is due to the fact that consumer will save money as a result of paying less for the tomato paste which they used to pay more for that item and additional consumption by new consumers (i.e., those who could not afford to buy before) as a result of lower price.
- The government, on the one hand, would lose VAT and tariff revenue from imports as a result of the import substitution by the consumers. On the other hand, the government would gain positive benefits in the form of the foreign exchange premium on the foreign exchange generated from additional exports and replaced imports, plus the VAT revenue on the expansion of domestic consumption after the project. In sum, the government will gain net benefit of 105.48 million pesos over and above its lost due to the project.

13.4.3 Case C: The Jamuna Bridge Project

The Jamuna, the Meghna and the Padma constitute a system of rivers that physically divides Bangladesh into East, Southwest and Northwest Regions. Most of the major centers within each region are connected by road or rail. All the connections between regions depend on the inland waterway transport system. The services provided at these river crossings is of poor quality, subject to many interruptions due to the adverse geographical and meteorological conditions and involving waiting time of up to many hours/days for freight traffic. In 1994, the Bangladesh government proposed to build a bridge over the Jamuna River to link east and west Bangladesh.⁷ The bridge was expected to facilitate economic growth within the country by improving the links between the relatively more developed region east of the Jamuna River and the agricultural region to the west. The project also allows transmission of electricity and transfer of natural gas between the East and the West regions.

Basic Facts about the Jamuna Bridge Project

The main features of the project include:

- The previous ferry services were poor, threatening the stability of inter-regional transportation system. The whole ferry system had reached its capacity limits creating delays ranging from one to eight hours for vehicles to 30/40 hours for heavy vehicles.
- The bridge was about 4.8 km long and 18.5 meters wide to carry four road lanes with sidewalks. Two bridge end viaducts were constructed, about 128 meters each, connecting the bridge to the approach road.
- The project was expected to cost approximately US\$696 million, including provision for physical and price contingencies.
- Approximately \$600 million of loans were given by bilateral and multilateral agencies to the Government of Bangladesh at a nominal interest rate of 1%. The rest of the financing was provided as a grant by the government.
- Implementation of the project began in 1996. The project life, for financial and economic evaluation purposes, is considered to be 50 years, counting from its opening to traffic in 1998.
- The average daily traffic in 1993 on the two relevant crossing channels (Aricha-Nagarbari and Bhuapur-Sirajganj) consisted of 271 buses, 140 light vehicles, and 770 trucks. The average annual growth rate of traffic in the bridge corridor was about 7.5% during 1986-1993. The annual traffic growth rates from 1993 to 1998 are estimated at 6.6% for buses

⁷ Detailed analysis can be found in Jenkins, G.P. and Shukla, G.P, "Linking East and West Bangladesh: The

and trucks, and 8.2% for light vehicles. From 1998 to 2025, the bridge traffic is estimated to grow at 5% per year. After year 2025, the traffic is assumed to have no increase until the 50th year.

- The economic benefits consist of the savings in vehicle operating costs and reduced waiting times plus the willingness to pay by newly generated traffic (as given by the tolls they are willing to pay). Financial revenues would arise from the tolls charged. This bridge would not only facilitate the transport of passengers and freight, but also enable natural gas, electricity, and telecommunication links to be made across the river.
- The foreign exchange premium was estimated to be 30.4% due to high tariff rates in Bangladesh.⁸
- The financial real cost of capital was estimated to be 10% while the economic opportunity cost of capital was estimated to be 12.1%.⁹
- As part of the financial and economic analysis, the option of improving the existing ferry service was considered.

Project Outcomes

The estimation of the distributional impacts of the Jamuna Bridge project was derived from the financial and economic analysis in the same way as the previous case of tomato paste production. Only a summary of the background analysis will be presented here for this case.

Comparing the financial profitability of the bridge project (with the specified set of tolls) with the existing ferry system indicated that the financial NPV of the bridge project would be a positive 1.07 billion Takas (US\$ 27 million).

An economic analysis was performed to determine whether the project would be beneficial to the overall economy of Bangladesh. The analysis revealed that as compared to the existing ferry system, the real economic NPV of the bridge project was 7.77 billion Takas (US\$ 195 million).¹⁰

When comparing the economic and financial analysis of this project, it was found that the major

Jamuna Bridge Project”, *The Canadian Journal of Program Evaluation*, Special Issue (1997), pp. 121-145.

⁸ Jenkins, G.P. and El-Hifinawi, M.B., *Economic Parameters for the Appraisal of Investment Projects: Bangladesh, Indonesia and the Philippines*, Harvard Institute for International Development, (November 1993).

⁹ Ibid.

¹⁰ The Taka is the Bangladesh currency unit. In 1994, the exchange rate was 39.8 Takas/\$US.

net beneficiaries were the truckers, the producers and consumers of cargo, the power company and the bus passengers. On the other hand, both the government and aid agencies as well as the ferry operators would lose. Truck operators, shippers and consumers would realize savings of about 31.09 billion Takas, while bus passengers and light vehicle owners and passengers would gain only 1.95 and 0.63 billion Takas, respectively. The present ferry operators would incur a negative financial impact amounting to 1.84 billion Takas, as the ferry services are replaced by the bridge.

Table 13.7 summarizes the allocation of externalities of this project among stakeholders, all discounted at the economic opportunity cost of capital.

**Table 13.7 Allocation of Net Benefits for the Jamuna Bridge Project
(millions of Takas in 1994 Prices)**

Total Net Benefits	Light Vehicles Passengers	Bus Passengers	Truckers, Producers and Consumers of Cargo	Power Company	Government and Aid Agencies	Locality	Ferry Operators
7,132.3	627.0	1,951.6	31,094.1	2,544.3	-27,700.7	456.9	-1,840.8

Reconciliation of the Project

Using equation (13.1), we can summarize the analysis of this project as follows:

$$NPV^e = NPV^f + \sum PV(EXT_i)$$

$$7,774.9 = 642.5 + 7,132.3$$

A key feature of this project was the large amount of subsidized financing it received. As a consequence of these subsidies, the distributional analysis shows that the total subsidies amounted, in present value terms, to -27,700 million Takas. This is a result of the interest subsidy on the loan (19,851 million Takas), the government grant (2,455 million Takas) and the premium lost on the foreign exchange used to purchase traded goods components of the investment cost of the bridge (5,358 million Takas).

On the other hand, we find that the estimated benefits of truckers, shippers and consumers would

amount to 31,094 million Takas, which is more than the entire investment cost of the bridge.

These results indicate that if a tariff structure were designed that would capture the benefits received by the consumers and producers of the cargo, little or no subsidy would have been needed. Perhaps for economic development and distributional reasons, it would be desirable to allow the users of the bridge to receive a substantial portion of the benefits from the bridge. In a country like Bangladesh, however, there are many pressing social and economic needs which are not being met due to a scarcity of resources. Perhaps the overall development impact of these \$600 million of low cost loans might have been greater if a somewhat smaller subsidy had been provided to the Jamuna Bridge Project. For example, the funds might have been better used to subsidize other public investments, such as education and health, where the application of user fees may be more difficult to implement than in the case of a bridge.

When considering the potential sustainability of this bridge, in terms of maintenance and construction of access roads, it is clear that sufficient funds could be generated by tolls to cover these costs. For this bridge, the maintenance of the river infrastructure and the construction of access roads will be critical for the success of its long term operation.

13.5 Conclusion

The type of integrated financial, economic and distributive analysis proposed in this chapter has a number of advantages for evaluating both public as well as private sector investments. First, it assures that the economic and financial analyses are done in a consistent manner. If the economic and the financial analyses are done correctly, then the differences will be equal to a series of distributional impacts that can be identified and measured. By following the format presented in this chapter, the possibility of error in completing the analysis can be substantially reduced.

Second, the clear identification of the stakeholders and how they will fare as a consequence of a project is a key ingredient in determining the likelihood of its successful implementation, as well as in causing the authorities to consider redesigning the project so that the impact on stakeholders is more favorable. Although most projects will have negative impacts on some segments of the population, if they are clearly identified and their political strengths assessed, the chances of surprises and stalled implementation may be substantially reduced.

Third, this analysis can also be used to identify the likely impact that a project will have on the incidence of poverty in particular groups. In the case of the Workers' Transportation project, the workers who will benefit are likely to be from the lower end of the income distribution. In the case of the Tomato Paste factory a major beneficiary group is the farmers who produce the tomatoes. As small holders they will tend to be from the poorer segments of the society. Likewise, bus passengers, truckers, producers and consumers of cargo services have gained substantial benefits from the implementation of the Jamuna Bridge project.

This analysis may not address all the questions of a political economy nature in determining what projects should be selected and implemented, but at least it provides a quantitative basis for making judgments as to the attractiveness of the project, and helps assess the roots of support and opposition that the project is likely to receive.

If projects are to be sustainable, they should not be subject to continued political pressure for their suspension. The stakeholder analysis, which we undertake through the comparison of the economic and financial outcomes, provides us with a clear signal of the groups which are likely to promote and those which will not favor the project. Through the identification of the fiscal and stakeholder impacts of the project, it is possible to make a more realistic assessment of successful implementation. In addition, if the project inflicts a continuous fiscal drain on the public sector budget, it is likely to be at some risk of losing this financial support in the future. Hence, such subsidies put at risk a project's long-term sustainability.

Appendix 13A

Economic Aspects of Foreign Financing

13A.1 Introduction

Large-scale, capital intensive projects frequently rely on foreign financing and as a result the foreign-owned segment of many sectors has grown considerably. New projects either reallocate the existing foreign investment within an economy or draw increment foreign investment into the country. Conventional methodologies for the economic appraisal of projects have usually recommended that the source of the funds used for financing of the project, either domestic or foreign be ignored. This assumption is increasingly being called into question as foreign investors and operators have increasingly dominated the private provision of public services. Many of these BOT and BOO contracts are far from being transparent capital market transactions. Hence, the form of the arrangement will have a different economic cost as they involve different flows of resources in and out of the host country. This appendix outlines a methodology for estimating the nature and magnitude of the net economic benefits, which may result from the foreign financing of new investments; such net benefits should be included in the overall economic evaluation of a project.

Public concern over foreign ownership has often focused on the issue of possible foreign control of a country's economy and interference with decision-making that would otherwise have been in the domestic economy's best interests.¹¹ Although we recognize the importance of such issues, we limit our examination to estimating the net economic benefits (costs) resulting from changes in the pool of capital resources available to a country due to the use of foreign financing for the project. Negative political externalities resulting from foreign control also may add to the economic costs arising from changes in foreign investment, as they might also cast a shadow over a project that would otherwise have created substantial net economic benefits for the country.

The economic benefits and costs of a project should initially be examined regardless of the source of financing. The economic opportunity cost of capital (EOCK) should be used as the economic discount rate for evaluating the economic costs and benefits that occur to the project overtime.

¹¹ For an excellent discussion of some of the historical experience of conflict between foreign investors and sovereign governments, see Wells, L.T. and Gleason, E.S., "Is Foreign Infrastructure Investment Still Risky?", *Harvard*

The EOCK is the measure of the real opportunity cost of the funds that are drawn out of the pool of capital available to the country to finance investments. This pool of capital will include both domestic and foreign owned funds.

From a global perspective if a new investment opportunity is financed from foreign sources, the net economic benefits from the project (discounted by the economic opportunity cost of capital) are going to be shared not only by the government (g) and the other residents of the country (p) but also by foreigners (f). In net present value (NPV^e) terms we thus have:

$$NPV^e = B_g + B_p + B_f - C_g - C_p - C_f \quad (13A.1)$$

where B and C represent gross benefits and costs, respectively. Benefits realized by the government (B_g) take the form of such items as taxes and fees paid to the treasury. Benefits realized by the foreign investors (B_f) comprise the debt repayment, interest, and dividend payments. B_p denotes the benefits accruing to the non-government sectors of the host country. All valuables are expressed as present values. Since we want to evaluate the economic performance of the project from a perspective of the host country only, it is necessary to adjust the net economic benefits for the benefits and costs realized by foreigners.

To make this adjustment in the appropriate manner, however, we must also ascertain whether our project has simply reallocated the existing foreign capital in the country, or has it attracted incremental foreign investment into the country. A normal supply function of foreign financial capital to any country has a finite elasticity. The implication is that the use of foreign owned capital for a specific project makes additional foreign investment more expensive to attract. Some fraction of the foreign investment for our projects will thus result in a move away from foreign financing of other projects, and some fraction will likely be an incremental addition to the total quantity of foreign financing obtained by the country. The normal cost of these funds as measured by the capital market is included in the EOCK for a country. The estimate of the EOCK, however, does not capture the net economic benefits (costs) resulting from foreign investment that arise due to the special characteristics of the project and the idiosyncratic nature of the financial agreements that determine the ultimate return to the foreign investors.

13A.2 Measurement of the Benefits from Incremental Foreign Investment

Foreign investment can be considered incremental to a host country when it is specific to a project, and when the project would not be undertaken unless the foreign capital was available. Furthermore, the attraction of foreign investment to this project does not affect the ability of the country to service its other foreign owned financial obligations. This suggests that the project is not available to other foreign investors and that the project itself will generate enough incremental foreign exchange to service this investment. In economic terms, the combination of this project and its funding causes the supply curve of foreign financing to the country to shift by an equal amount to the right. In this sense foreign financing of the project is incremental to what foreigners would otherwise invest in the host country.

If the foreign investment is incremental, the host country should not be concerned over how much the foreigners put into or take out of the project. It should ensure, however, that the host country's resources, which are employed in the project along with the foreign capital, earn an economic rate of return at least as great as they could have earned in alternative uses. This is accomplished by evaluating all resources at their economic opportunity cost and by discounting all relevant costs and benefits by the economic opportunity cost of capital. Since our evaluation of a new investment opportunity adopts a host country point of view, we simply want to exclude C_f and B_f from equation (13A.1) by adding $(C_f - B_f)$ to it as follows:

$$NPV = NPV^c + (C_f - B_f) = B_g + B_p - C_g - C_p \quad (13A.2)$$

Since the incremental foreign capital (C_f) also provides incremental foreign exchange, the additional foreign investment carries an additional premium (FEP) to reflect the difference between the economic opportunity cost of foreign exchange and the market exchange rate.¹² By the same token dividends, interest, and loan repayments made to foreign investors' (B_f) entail a loss of foreign exchange, which also results in a loss of the foreign exchange premium. Foreign owners of the capital in their return do not capture the net foreign exchange externality that

¹² Harberger, A.C. and Jenkins, G.P., "Introduction" edited by Harberger, A.C. and Jenkins, G.P., *Cost-Benefit Analysis*, Cheltenham: Edward Elgar Publishing Limited, (2002), and Harberger, A.C., Jenkins, G.P., Kuo, C.Y. and Mphahlele, M. B., "The Economic Cost of Foreign Exchange for South Africa", *South African Journal of Economics*,

accrues to the host country as a result of foreign investment. As the foreign exchange externality from foreign financing not included in the NPV^e of net benefits from the project, we must add $(FEP)(C_f - B_f)$ to both sides of the equation (13A.2) to yield the adjusted economic net present value NPV_a^e :

$$NPV_a^e = B_g + B_p - C_g - C_p + (FEP)(C_f - B_f) \quad (13A.3)$$

The total adjustment to equation (13A.1) made necessary by incremental foreign investment, $(1+FEP)(C_f - B_f)$, will raise or lower the present value of net economic benefits to host country depending on whether $(1+FEP)(C_f - B_f)$ is positive or negative. If $B_f > C_f$, for example, the stream of dividends (net of withholding tax) plus interest and debt repayment is sufficient, when discounted at the EOCK, to permit foreigners to recapture their investment and to earn a rate of return greater than the EOCK. The result is that the economic net present value from the point of view of the host country will be less after making the adjustment for the cost of incremental foreign investment than before the adjustment is made. If after making the adjustment we find that the economic net present value NPV_a^e is greater than zero, the host country should permit the project. If on the other hand, the NPV_a^e is less than zero, the country is going to be made worse off by this project and it should not go forward.

13A.2 The Benefit from Reallocating Foreign Investment Already Present in the Host Country

As noted above, a normal supply function of foreign financial capital to a host country has a finite elasticity. In the previous section, we adopted the extreme assumption of allowing all the foreign investment for a project to be incremental to the host country. In this section, we go to the opposite extreme by assuming that foreign investment for a project results only in a reallocation of foreign investment away from other projects in the host country. It is assumed that the project will go ahead even without the foreign investment, we then need to know whether the country is better off to use the foreign capital for this specific project rather than in alternative projects.

When none of the foreign investment for our project is incremental to the host country, but only reallocates the existing pool of foreign capital resources away from other projects, we must adjust equation (13A.1) in a different fashion. As before, the present value of the benefits foreigners receive from their investment (B_f) is the stream of dividends, interest and loan repayments, discounted at the EOCK that actually flows from the project. The relevant opportunity cost of the investment for the foreigners is the stream of benefits that they would have received from the alternative investment foregone (B_f^a).

The benefit to foreigners from alternative investment in the host country is equal to the present value of the real (net of inflation) returns these investments would have earned. Since foreign-owned capital is part of the host country's capital stock, it is reasonable to expect that foreign investors would earn a rate of return roughly equal to that earned on the total capital stock in the host country. We shall denote the private discount rate that makes the net present value of the net-of-tax net cash flow to total capital equal to zero as r_f .¹³

In the case where the foreign investment is non-incremental, a greater than normal return to foreigners represents a net cost to the economy. In contrast, a foreign investor may be willing to make an investment and receive a lower than normal rate of return (for example, if the investment is of great strategic importance to the firm). In this case the participation in the financing by this particular foreign investor will increase the economic net present value of the project.

The level of political risk that foreign investors face with a particular project may mean that they will require a higher or lower than normal rate of return from a particular project.¹⁴ There is strong evidence that foreign investors considering investing in electricity projects in some countries have required higher than normal rates of return due to the perceived political risk they are likely to face in the future with such projects.¹⁵ In other cases, foreign investors might face restrictions on the length of the term of debt financing available for a project. This may mean that the price set for the project's service has to be set very high initially in order to make the debt

¹³ For example, in the Philippines the value of r_f has been estimated to be approximately 9.75 percent. Jenkins, G.P. and Kuo, C.Y., "Estimation of the National Parameters for Economic Cost-Benefit Analysis for the Philippines", Development Discussion Paper, Harvard Institute for International Development, Harvard University, (May 1998).
¹⁴ Wells, L.T., and Gleason, E.C., "Is Foreign Infrastructure Investment Still Risky?", *Harvard Business Review*, (September-October 1995).

¹⁵ Jenkins, G.P. and Lim, H.B.F., "An Integrated Analysis of A Power Purchase Agreement", Development Discussion Paper, Harvard Institute for International Development, Harvard University, (1998).

service obligations. Over time the debt will be repaid, but the continuation of such pricing policies might cause the foreign equity holders to earn an extraordinary high rate of return.

In either of these circumstances, the project might still have a positive economic NPV from the host country's point of view after making the adjustment for the higher than usual returns that have to be paid to these particular foreign investors. In such a situation, the host country evaluators of the project should first consider alternative methods of managing the risks or consider alternative financial structures, before giving final approval to the project.

If by investing in a specific project foreigners earn a real return just equal the average of r_f , then the ratio (Z) of the present value (discounted at r_f) of the stream of foreign equity and debt invested in the project over the present value (discounted at r_f) of the foreign dividends, debt repayment and interest received (equation 13A.4) would equal 1. If this ratio (Z) were greater than 1, then foreigners would be earning less than a r_f return by investing in the project; if the ratio were less than 1, then foreigners would be earning more than a r_f real return.

$$Z = \left[\frac{\text{PV (foreign equity + foreign debt) at } r_f \text{ discount rate}}{\text{PV (foreign dividend + foreign interest + foreign repayment) for project at } r_f \text{ discount rate}} \right] \quad (13A.4)$$

By multiplying this ratio times the actual stream B_f^t (where $t = 0, \dots, n$) of dividends, debt repayment, and interest received from foreigners from the project, we can determine the stream of payment to foreigners which is below, above, or equal to what the normal stream would be B_f^{at} (where $t = 0, \dots, n$).¹⁶ Discounting the difference between these two streams ($B_f^{at} - B_f^t$) by the EOCK for the country yields our estimate of the present value of the externality E_f enjoyed or (imposed) on the country because the foreign investment in this specific project will demand a return that lower or (higher) than what is normal in the market.

Following the reasoning used in the previous section, the total adjustment we must make in this case is to add $(1 + \text{FEP}) E_f$ to equation (13A.1). Hence, equation (13A.1) becomes:

$$\text{NPV}^e = B_g + B_p + B_f - C_g - C_p - C_f + (1 + \text{FEP}) E_f \quad (13A.5)$$

¹⁶ The stream of dividends, debt repayment, and interest received are all measured in constant dollars.

When the ratio of the present values, Z , is equal to one, our project yields foreign investors just a normal return and no adjustment to equation (13A.1) is necessary.

If, however, if Z is greater than one, then $E_f > 1$ and therefore $(1+FEF)E_f > 1$. This suggests that the project should receive a net benefit for paying out less to foreigners than the country would have if it had used the foreign financing for alternative investments. Since this case also implies that private investors earn less than a normal real rate of return of r_f , we must pause to consider some other factors before adding this net benefit to the economic externalities attributable to the project.

A critical factor in determining the rate of return that a foreign investor demands before making the investment is the economic cost of any explicit and implicit guarantees the project or the investor receives from the country (usually the government).¹⁷ The guarantees that are designed to remove risk from the perspective of the foreign investor may cover a wide range of issues. Examples include completion guarantees, loan guarantees, and the contractual allocation of the foreign exchange rate risk to either the government or consumers.¹⁸ These guarantees have associated with them real economic costs that usually are not explicitly accounted for in the cash flows of the project.¹⁹ Hence, while it may appear that the foreign investor is willing to make funds available at an abnormally low required rate of return, it might be simply be that the government is bearing a larger proportion of the financial risks than is normal for such investments.

Another factor that often is present in the foreign financing of investment projects is financing subsidies given by foreign governments to promote certain types of investments abroad. If these subsidies are included, it might appear that a host economy is receiving a substantial benefit because the project attracts this subsidized financing.

¹⁷ Vega, A.O., "Risk Allocation in Infrastructure Financing", *The Journal of Project Finance*, Vol. 3, No. 2, (Summer 1997).

¹⁸ A good example of the allocation of foreign exchange rate risk to consumers can be found in the Concession Agreement between Metropolitan Waterworks and Sewerage System and the private contractor in the case of the privatization of the water systems in Manila. In this case any movement in the nominal exchange rate between the peso and the currency of the loans that was greater than 2 percent from the date of the agreement would be built into the adjustment for the price of water. It is not surprising that the concessionaires borrowed large amounts of funds in Yen, the currency that was likely to appreciate the most with respect to the peso.

¹⁹ Mason, Scott, Baldwin, C. and Lessard, D., "Budgetary Time Bombs: Controlling Government loan Guarantees",

It is generally incorrect to include any foreign (or domestic) financing subsidies as a benefit (or a reduction in financing costs) to any single project. Usually such financing subsidies are provided to countries through a quota system, where it will not be able to get more than a given amount of such subsidies over a period of time. From the point of view of the promoter of any single investment in the host country it might appear that these foreign financing subsidies are either bringing in incremental foreign financing, or are at least a reduction in the cost of foreign financing that would have been available to the host country. In both cases it is incorrect to credit the financing subsidy provided to any single project within a country.

13A.4 Concluding Remarks

The central issue in the evaluation of the benefits or costs to an economy from foreign financing of investments is the determination of the proportion of the inflow of foreign financing to project that is simply a substitute for other foreign capital inflows, and the proportion that represents an increase in the productive resources available to the host country. Because the economic cost of incremental and non-incremental foreign investment may be quite different, the relative size of this parameter can be a critical determinant of the economic net present value of a project.

A difficulty that plagues the empirical estimation of the proportions of the foreign investment that are incremental and non-incremental arises because the impact of today's foreign investment on the demand and supply of foreign saving need not be completed within a given period of time. In addition, the nature of the various types of financial obligations undertaken by a country will alter the impact of the inflow of foreign savings on the investment and saving decisions in the country over extended periods of time.

Because of the serious statistical problems that arise in the derivation of reliable estimates of the long-run effects of foreign investment on capital formation, and the plethora of unaccounted for implicit and explicit guarantees associated with many projects, caution is warranted before crediting a project either for inducing incremental foreign investment or for securing low cost foreign financing. In the vast majority of cases, a project that is being financed from foreign sources will be simply reallocating the total amount of foreign investment available to the

country. This arises due to the constraints on a country's ability to repay its foreign financial obligations. In such a situation, the main concern of the project evaluator is to determine if this project is being structured in such a way (or is attracting the type of foreign investor) that will require a greater than normal rate of return to participate in this project. In this case the economic analysis should reflect this higher cost and the particular financial design of the project appropriately penalized.

Factories that are being set up in an export-processing zone can illustrate a case where a project is likely to create incremental foreign investment. In such a case, the primary concern of the project analyst is to see that the domestic resources being used to accommodate this foreign investment are yielding a net return of at least equal to the economic opportunity cost of capital. The foreign investment coming in to finance the factory is a benefit to the country and the flow of interest, dividends and loan repayments are costs, The question here is, does the domestic labor and capital being employed earn a return greater than their economic opportunity cost?

Probably the most important reason for not giving a benefit to a project for non-incremental foreign investment that appears to have been made available at lower than normal costs, is the existence of complex guarantee provisions that are at the heart of all project financing arrangements. In such a situation the costs of financial risk may be reflected in other charges to the project separate from the rate of interest and expected dividends. Often the costs of risk management are being borne by the government, and are not allocated in any way to the project. It is the economic costs of these guarantees that need to be the focus of the analyst's attention.

Guarantees that are provided by the government to domestic investors may alter behavior and damage or help a project, but the triggering of the guarantee is essentially a transfer from the government to the domestic financial institutions within the country. This could have little or no economic cost. This is not the case with guarantees made to foreign investors. When such a guarantee is exercised, the flow of funds is an outflow of economic resources. In this case, the expected economic cost to the economy is increased above what it would be if no guarantee were given.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 14:**

*THE SHADOW PRICE OF GOVERNMENT FUNDS,
DISTRIBUTIONAL WEIGHTS, AND BASIC NEEDS EXTERNALITIES*

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ABSTRACT

There is always a question, in cost-benefit work, about how far to go in incorporating additional externalities into a formal system of professional analysis. One consideration is the importance of the class of externalities in question; the alternative consideration is the degree of uncertainty that surrounds any estimate of the size of the externality. This chapter addresses three such externalities that have been widely discussed in the literature, but usually not applied in practice. Of the three the shadow price of government funds is likely to be the most important in terms of its impact on the design of public sector projects.

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CHAPTER 14
THE SHADOW PRICE OF GOVERNMENT FUNDS,
DISTRIBUTIONAL WEIGHTS, AND BASIC NEEDS EXTERNALITIES

14.1 Introduction

There is always a question, in cost-benefit work, about how far to go in incorporating additional externalities into a formal system of professional analysis. One consideration is the importance of the class of externalities in question; the alternative consideration is the degree of uncertainty that surrounds any estimate of the size of the externality. Thus even important externalities (such as those dealing with national defense) can be too difficult to quantify for them to be incorporated directly into a cost-benefit analysis. In such cases the best advice is to calculate the net present value of the project using standard cost-benefit analysis, and present the policymakers with a statement like “This project has a net economic cost (in present value terms) of \$3.5 billion. This does not incorporate its national defense benefit. Your decision, sirs, concerns whether the cost of \$3.5 billion is worth incurring, as the price for achieving the national defense benefits of this project.” A similar approach would very likely apply to projects dealing with offsetting some of the forces leading to long-term climate change and to many (though not likely all) cases of projects that deal with air or water pollution.

Our judgment in this matter is simple. When our information about the size of an item is so uncertain that some valuations, well within the plausible range, would make the project acceptable, while others, also well inside the plausible range, would lead to its rejection, then the final call in that project is not within the purview of professional cost-benefit analysis.

Of course, the constant challenge facing the profession is that of developing analytical and research techniques that will constantly narrow the ranges of uncertainty that we have to deal with. Thus, there have been impressive advances developing methods of quantifying the value of travel time (by commuters and others), and the amenity value of local parks and other neighborhood improvements. And we certainly can expect additional advances that will further

narrow the margins of uncertainty that apply in different fields. But at the same time we can be confident that in many major areas, the level of uncertainty will continue to be high for a long time to come. Our advice here focuses on the key word, professionalism. We should incorporate into our analysis whatever we can claim to be based on solid professional results and judgments, and leave to others those items on which we have no serious professional expertise.

In the cases of some externalities there may be a sort of middle ground. There are cases where an externality of a given type can be summarized in one or a few key parameters, which themselves can then be fitted quite easily into our professional cost-benefit framework. In this chapter we will consider three candidates that fall in this category: a) the shadow price of government funds, b) the distributional weights that might be applied to the benefits and costs of different groups, and c) the premia that might be attached to the successive steps of increased fulfillment of the basic needs of disadvantaged members of a society.

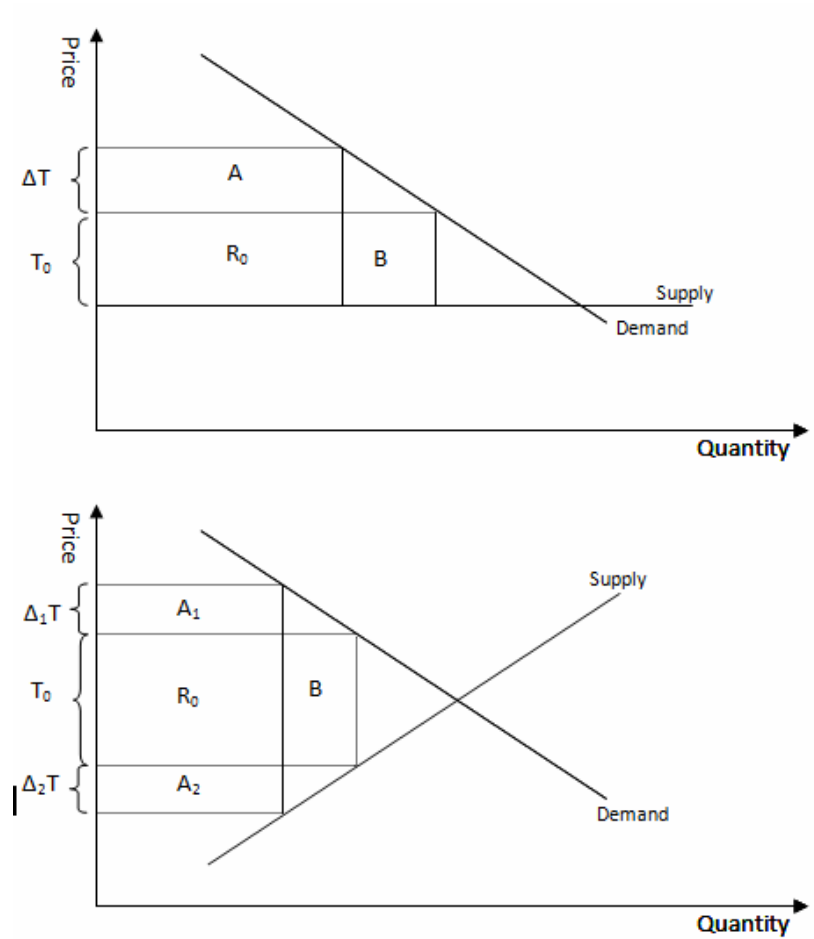
14.2 The Shadow Price of Government Funds

Cost-benefit analysis has traditionally been carried out on the assumption that the funds involved were being sourced in the capital market. And indeed, this is the assumption made in this Book (see Chapter 8 on the economic opportunity cost of capital). This assumption is easy to rationalize when the projects involved yield their full benefits in the form of cash accruing to the public treasury (e.g., an electricity or potable water project, with electricity rates and water charges set on the basis of economic principles). However, how does one deal with public projects that yield no revenue in the form of cash? In such cases the standard assumption of getting the money from the capital market seems to lead to a debt which then grows year after year, compounded at a rate equal to the economic opportunity cost of capital. If the latter rate is 10% (in real terms) that means a project for an ordinary highway (not a toll road) that cost \$20 million, would compound to a debt of \$40 million after 7 years, \$80 million after 14 years, \$160 million after 21 years, and \$320 million after 28 years. If the economic cost of capital were 7%, the debt would reach \$40 million after 10 years and \$320 million after 40 years. In light of these

numbers, it is pretty clear that “something should be done” to tie up this loose end in the cost-benefit framework.

The answer is quite straightforward and logical. Somewhere, somehow, the framework should make provision for such debts to be paid. And the natural source for paying them should be taxes. This would require no adjustment if getting extra dollars via the tax route implied an economic opportunity cost of one dollar for every additional dollar raised. However, this is far from being the case in reality. Figure 14.1 shows why. In the upper panel, the tax T_0 originally yields revenue of R_0 . When this tax is raised to $T_0 + \Delta T$, revenue goes up by $A - B$. There is also an increment to efficiency cost, which can be approximated by B . Thus the extra efficiency cost, per dollar of additional tax revenue, is $B/(A - B)$. In the lower panel we have an upward sloping supply curve. The rate now goes up from T_0 to $(T_0 + \Delta_1 T + \Delta_2 T)$, and tax revenue goes up by $A_1 + A_2 - B$. Efficiency cost per dollar of extra revenue is in this case $B/(A_1 + A_2 - B)$.

Figure 14.1



For small changes in the tax rate the increment of efficiency cost is $-\tau(\partial q/\partial t)dt$, and the increment to tax revenue is $qdt + t(\partial q/\partial t)dt$. The ratio of these is simply $-e_{qt}/(1+e_{qt})$ where e_{qt} is the elasticity of quantity with respect to the tax rate, and is a negative number. Thus if e_{qt} is $-.20$, the marginal cost of extra revenue is 25 cents $[=.20/(1-.20)]$ per dollar. If e_{qt} is $-.25$, this marginal cost is 33 1/3 cents $[=.25/(1-.25)]$ per dollar. And if e_{qt} is $-1/3$, then the marginal cost of extra tax dollars is 50 cents $[=.333/(1-.333)]$ per dollar.

The expression for the marginal economic opportunity cost of extra tax revenue is simple enough. The problem is that this number is likely to be different for every single tax in the system. Indeed, for complicated taxes like the personal income tax, there are literally hundreds of

different adjustments that could be made to the tax law, each of which would carry a different efficiency cost per extra dollar of revenue. We see no way of predicting what form the next change in tax law will take, hence no way to select from among all the possible ways, a particular one which we would want to call the “standard” way of raising extra tax revenue.

Now we face a problem. We do not want to choose a standard route for raising extra revenue, yet if we do nothing, we are implicitly assuming that the marginal efficiency cost of extra tax revenue is zero. This, of course, is also unacceptable.

Our solution is for the country’s project evaluation (cost-benefit) authority to make that choice. Our recommendation is for the choice to lean toward the conservative side, so that the chance of its marginal cost of tax revenue being too high would be smaller than the chance of its being too low. In order to have a specific number to deal with, we will use a marginal cost of funds equal to 1.20, which implies an elasticity of the tax base (quantity) with respect to the tax rate of $-1/6$ (see above). We should also note that when this assumption is applied to real-world cases, the tax-base elasticity should incorporate increases in evasion as tax rates are raised, as well as the simple substitution of other items for the taxed item. Moreover, real-world efficiency costs of taxation should be defined to include the incremental costs of administration and compliance that are induced when a given tax rate is raised.¹

14.3 Distributional Weights

In discussions of issues of how public policy should treat different groups of citizens, a particular approach, that of distributional weights, has enjoyed some degree of prominence. This approach applies different weights to the benefits and costs perceived by different groups of participants in the economy. Normally, higher weights apply to the poor and disadvantaged, lower weights to wealthier groups. The idea of such weights is appealing to most people, because they

¹Some empirical results for the efficiency costs of tax on labor income are Dahlby (Canada), 1.38; Futm & Lacross (Quebec), 1.39-1.53; Jorgenson & Yun (U.S.), 1.35-1.40; Gruber & Saez (U.S.), 1.28; Klever & Kremer (U.K), 1.26, (Italy) 1.72, (Germany) 1.85; Hansen & Stuart (Sweden), 1.69. See, e.g., Dahlby, B., *The Marginal Cost of*

instinctively feel that an incremental dollar going to a richer person should be thought of as being less valuable, from the point of view of society as a whole, than the same dollar going to a poorer person. Sometimes this idea is embodied by the concept of a representative utility function, in which the marginal utility of extra money is calculated to decline as people's income or wealth increases.

Traditional applied welfare economics did not incorporate distributional weights; even while recognizing the likelihood that each individual's or family's marginal utility of income may decline as income or wealth increases. It did not take any complex analysis to get to this point. Actually, it followed directly from the choice of a numeraire in which real economic values were expressed. The standard numeraire for most real-world applications is either the consumer price index or the GDP deflator of the country under study. Thus, real economic magnitudes are either expressed in "consumer baskets" or in "producer baskets". When economic costs and benefits are expressed in terms of one or the other of these two numeraires, the translation from individual utility into units of the numeraire basket is implicitly made at the individual level. Individual A's utility is translated into numeraire baskets using A's marginal utility of the basket. B's translation occurs using B's marginal utility of the basket, etc., etc. for all the relevant individuals. There is no need for utility units even to be comparable across individuals, in order for this process to work.

Distributional weights can still be introduced into this framework, not being thought of as measures of the utility of each relevant individual, but instead as reflections of a societal decision of the importance of incremental purchasing power, as it flows into or out of the hands of particular individuals and groups. This way of framing the concept helps to avoid what was a particularly gnawing problem, when the weights were interpreted as directly measuring utility. That problem is most easily illustrated by a case of constant supply price, of, say, construction labor. The constant supply price means zero producer surplus is generated as additional labor is hired for a public project, yet the families involved may indeed increase their cash income by

Theory and Applications, Cambridge: Massachusetts Institute of Technology Press, (2008). Typically, studies such as those cited above have no allowance for evasion or for costs of administration.

part or all of the cash wages paid out by the government. Actual practice would normally assign these cash wages, adjusted by the relevant distributional weight as a benefit, and consider the supply price of the labor (its cash wage) as an economic cost. This is not correct if the relevant “base” for the distributional weight is the utility gain linked to the increased employment. But it is justifiable if the relevant base is the purchasing power in the hands of the workers or their families.²

In our opinion, the principal weakness of the distributional weights approach derives not from the idea of these weights as such, but rather from the patterns of weights that have typically been assumed in the expositions and applications that appear in the economics literature. To make our point very briefly: modest differences in weights do not cause serious problems, but large differences in weights do indeed entail such problems.

Any actual or implicit transfer of purchasing power from richer (low weighted) persons to poorer (higher weighted) persons can be thought of as an implicit approbation of economic waste, in an amount whose magnitude is governed by the size of the differences between the weight of the “donor” and the weight of the recipient. Thus, a project or other operation which reduces the income of A by 1,000 would have a weighted cost of 500 if A had a distributional weight of 1/2. If that project also caused the income of B to increase by 300, there would be a weighted benefit of 600, if B had a weight of 2. We could thus have:

Efficiency Benefits (measured without regard to distribution)	3,000
Efficiency Costs (measured without regard to distribution)	<u>3,700</u>
Efficiency NPV	-700
Distributional Externalities (weighted cost of A is 500, vs. unweighted cost of 1,000)	+500
Distributional Externalities (weighted benefit of B is 600, vs. unweighted benefit of 300)	<u>+300</u>

² This treatment helps to partially bridge the gap between the distributional weights approach on the one hand and that of basic needs externalities on the other (see below for an exposition of the basic needs approach).

Distributional NPV	+ <u>800</u>
Weighted NPV of Project	+100
Unweighted NPV of Project	-700

The assertion of a distributional (or any other) externality really means a willingness to accept (if need be) a net loss in efficiency terms, of up to the full size of that externality. Of course it does not require but nonetheless invites such an efficiency loss. Put another way, distributional considerations do not modify a decision on a project if efficiency considerations alone would lead to the same answer. Thus, to the extent that a distributional externality has an impact on the result, it necessarily must be operating to offset an efficiency cost, up to the full size of the externality.

This line of thinking has extremely powerful implications. Let us simply consider two groups, those (A) with distributional weights less than 1/2, and those (B) with weights greater than 2. Clearly it would “pay”, in the sense of being acceptable from society’s point of view, to undertake every independent project or program that brings about transfers from group A to group B, so long as the efficiency cost linked to that project was less than 3/4 of its budget. Hearing this usually bothers listeners and their instinctive reaction is to ask, can’t we get the same transfer at much lower cost than that? If a lower cost is indeed possible, the answer is to narrow the range -- say, by taking from those with weights less than 2/3 and transferring to those with weights greater than 1.5. Under this rule, the weighted cost of taking 900 from group A would be 600, and the weighted benefit of giving 400 to group B would be 600. Thus an efficiency cost of up to 500 (= 5/9 of the amount taken from the “donors”) would be “invited” by the scheme.

Following these general lines, which are implied by a distributional weights approach, would typically lead to huge transfers, so that in the end hardly anybody was left with incomes under a lower bound, and hardly anybody was left with incomes above an upper bound. The exceptions would probably be upper-income individuals from whom taking money would be very expensive in efficiency terms (e.g., high earners who would simply quit and move to another country in

response to a given scheme of transfer). But those who would simply reduce their effort modestly, or who would actually increase their effort in response to a fall in their net take-home income, would be easy targets for a “taking”.

The Achilles heal of a distributional weights approach arises when large differences in weights are associated with differences in income that appear to most people to be within a quite “normal” range. We do not see such a problem if all we do is give the bottom decile a weight of 1.3, the second decile a weight of 1.2, and the third decile a weight of 1.1, leaving everybody else with a weight of 1.0. But the optimal tax literature is full of applications in which the distributional weights are inversely proportional to income. In such a case one might have a weight of 1.0 applying to family income of \$60,000, a weight of 2 applying to an income of \$30,000 and a weight of 1/2 applying when income was \$120,000. Here a transfer from somebody with an income slightly above \$120,000 to somebody with an income slightly below \$30,000 would be OK, so long as its efficiency cost did not exceed 3/4 of the amount “taken”. If good diligence then uncovered ways of taking and transferring that “only” had efficiency costs of 5/9 of the amount taken, then most incomes above \$90,000 would one way or another be taken, and most people starting below \$40,000 would have their incomes supplemented up to that point.

It isn't that a distributional weights framework can be used, say, only for the purpose of setting an income tax schedule, and then be just put to one side and forgotten about, as it were, when evaluating other taxes, tariffs, agricultural price schemes, price controls, and rationing schemes, quite generally, and, of course the whole range of public expenditures (on both current and capital accounts). No, the spirit of cost-benefit analysis is that we apply it to each and every decision that comes along, in a context in which prevailing distortions are as a first approximation taken as given.

Weights that are inversely proportional to income “invite” too many transfers, and too costly transfers, for most people to accept. Inverse proportionality implies a weighting scheme in which the elasticity of the weight with respect to the income level of the subject is -1. Most of the examples in the tax literature deal with assumed elasticities in the range of -1/2 to -2. The case of

an elasticity of -2 is even more exaggerated than that of -1. An elasticity of -1/2 would be more generous. Here the weight of 1/2 would apply to incomes of \$240,000, and the weight of 2 would apply to incomes less than \$15,000, but as between these limits efficiency losses of up to 3/4 of the amount “taken” from the upper-income group would still be acceptable under a weighted cost-benefit test.

Pursuing the implications of exponential weighting patterns with elasticities in the indicated range leads to implied distributions of after-tax income that are far narrower than we observe in reality, and quite beyond what most people would regard as plausible. But distributional weights where the highest weight is, say 1 1/2 or even 2 times the lowest would be much less vulnerable to this sort of critique.

14.4 Basic Needs Externalities

Our thinking in terms of basic needs got started during a period (1970s and early 1980s) when the terms distributional weights and basic needs externalities were widely used, often being treated as alternative labels for the same general approach. We reacted against this, particularly since at that time our own vision of the distributional weights was the classical one, in which the focus was directly on the utility level of each relevant economic agent. We thought quite naturally of the example from economics texts and classrooms, which shows that if the utility of a recipient is the objective, then the most efficient way to enhance that utility is by giving money, which that person can then use to buy whatever bundle of goods and services (from among those thus rendered affordable) brings the greatest satisfaction. We noted, however, that the great bulk of transfers carried out by the public sector (worldwide, looking at all countries) turn out to be effectuated in kind rather than in cash. This led us to conclude that some motivation other than the pure utility of the recipients must be involved.

This led us to focus on the idea that the objective of many transfer operations is the welfare, not the utility of the recipients -- welfare being defined by someone other than the recipients themselves. This could be thought of as the voters, or the tax-payers, or their legislative

representatives, or just the government. The implicit thing is that the recipients' welfare is being defined by someone else, with that someone, in one sense or another trying to represent the tastes or judgments of "society".

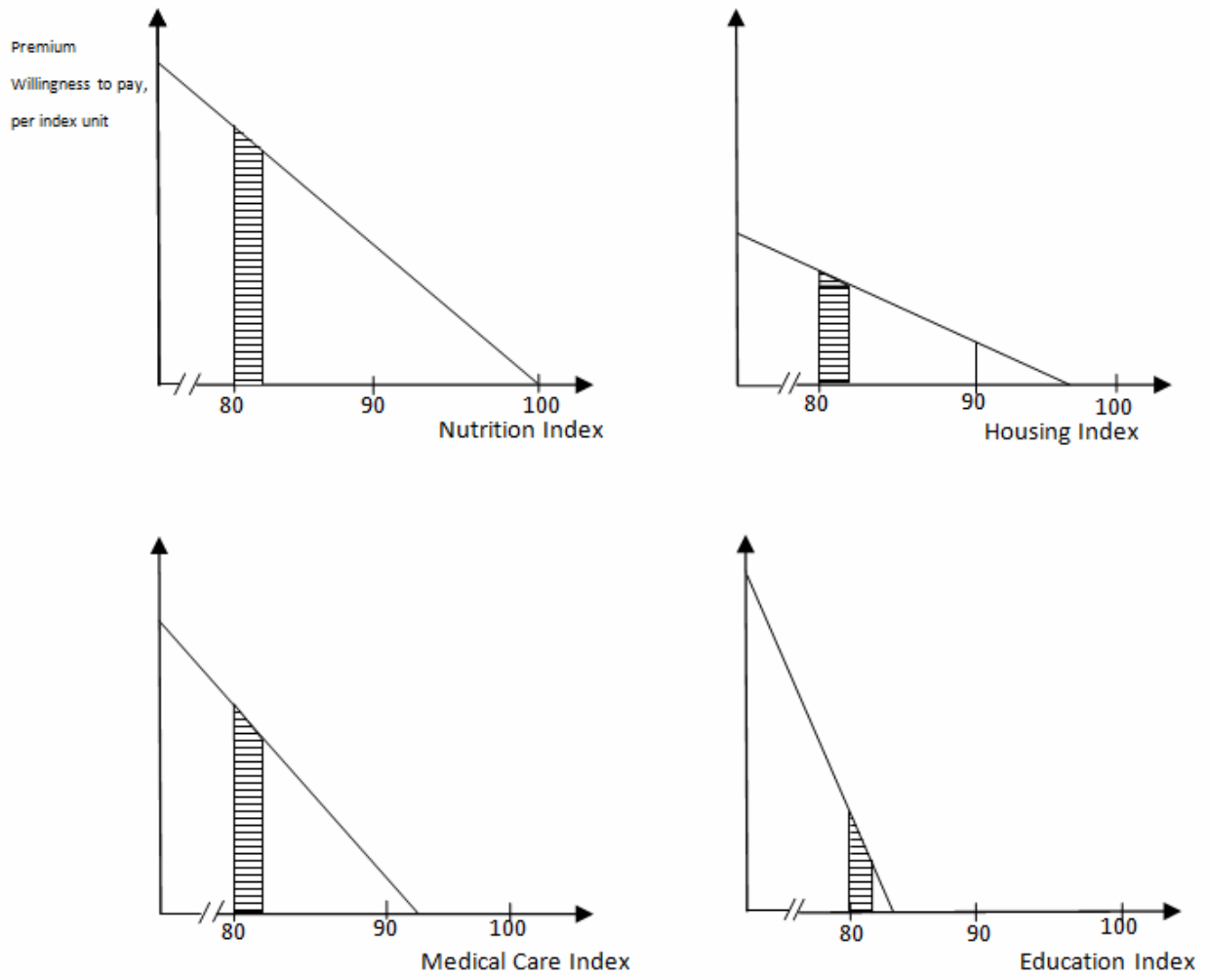
No transfer program is more widespread, across the entire world, than free primary education. Yet this is invariably, so far as we know, delivered in kind. Governments do not give, say \$1,000 per pupil to each child's parents, saying that they can use that money to pay for a year's education for their son or daughter, but they can also use it for a daughter's dowry, or to take a trip. No, educational transfers are delivered in kind. Voucher schemes, which are still quite rare, give parents money which they can freely use, but only to pay for their child's education. The freedom of choice is restricted to the educational realm, where in our opinion it meets an important basic need.

It is quite similar with respect to public programs for other basic needs. Medical care is quite clearly delivered in kind. So too is housing. Nutrition, yet another basic need, is sometimes delivered via soup kitchens or similar establishments (in which case it is clearly in kind), but sometimes delivered via subsidized prices or via food stamps. These latter cases differ from those of education and medical care, in that they are more readily subject to abuse by the recipients. In the U.S., for example, food stamps are often accepted by retailers in payment for non-food items. More blatantly, they are quite openly sold for cash in many places. If such evasion of the labeled intent of the subsidy is widespread, it effectively nullifies the basic needs justification, and turns the policy into one that is better supported by distributional weights arguments. We believe, however, that the basic needs motivations for food and housing programs are only partially frustrated. And we also believe that, to the extent that food stamps are sold, and subsidized quarters are rented out to non-family members (with the proceeds then being used for general purposes, unlinked to basic needs), most citizens and taxpayers who support these programs become quite annoyed, so much so that if they felt that these evasive measures were widespread, they would probably no longer favor the programs.

The basic needs approach, then, says that “society” is willing to pay a premium in order to more fully meet the basic needs of disadvantaged people -- to leave them more adequately fed, and with improved housing facilities, and better cared for medically, and/or with their children better educated. This premium reflects a willingness to pay more than the normal price, to bear more than the normal cost, to deliver elements that add to the fulfillment of the basic needs of the disadvantaged. Put another way, and as a direct reflection of what was said concerning the distributional weights approach, “society” is willing to put up with certain amounts of extra cost, or of economic inefficiency, if this makes possible the fulfillment of some unmet basic needs. The size of the premium assigned for a given basic need, and the definition of the base to which that premium applies, defines the precise tradeoff involved -- i.e., how much society is willing to pay for what specific sign of improvement.

Let us start with a rather idealized picture -- one that best displays the underlying rationale for basic needs externalities. This would be similar to using an idealized standard utility function, or a continuously declining relationship giving distributional weights as a function of real income, in a distributional weights approach. The counterpart in a basic needs setting is a function in which the horizontal axis measures an index of nutrition, of medical care, of housing or of education, and the vertical axis displays the premium that “society” is willing to pay for each successive increment of that index (see Figure 14.2).

Figure 14.2



The figure reveals several points. First, society may have different attitudes with respect to different basic needs. These are expressed (with linear curves) in the two intercepts. Both intercepts are highest, in Figure 14.2 for nutrition. In this case, society is willing to pay more for a 1-point gain in the nutrition index than for a similar gain in any other index at the same level, and is willing to keep paying up to an index level 100 (which we might take to be the national per capita median level). The education picture reveals a high willingness to pay at low levels of the index, but a willingness that disappears long before the median level is reached. This might reflect a situation in which the society places a high value on universal primary education, but is unwilling (or unable) to pay premia for secondary and higher education. To display the differences in another way, the shaded bars in the four graphs indicate the amount “society” would be willing to pay to lift one individual from index level 80 to index level 82, for each of the four basic needs categories. It clearly shows how substantial differences or priority can exist among the categories.

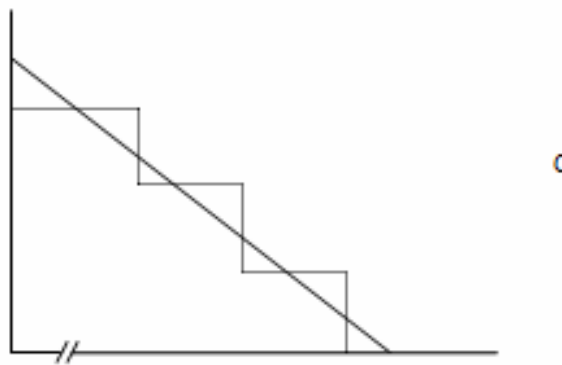
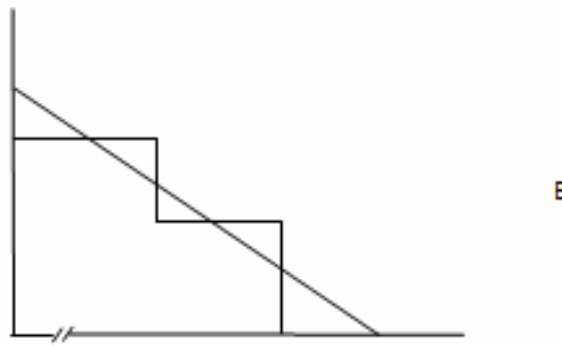
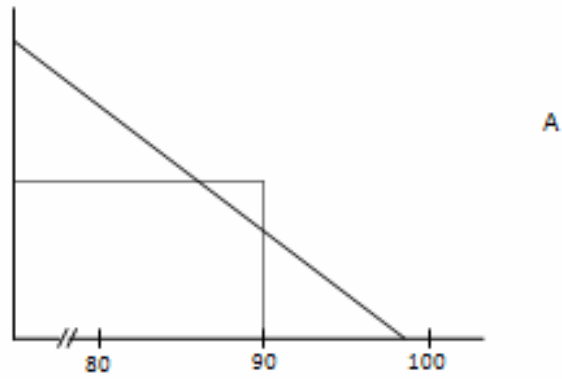
We feel that the framework shown in Figure 14.2 is important in laying the groundwork for a basic needs approach. Few would argue that the move from index level 90 to 92 should be valued as highly by society as the move from level 80 to 82. It is also quite reasonable that the “true” premiums representing society’s true willingness to pay, should decline continuously with each additional step of fulfilling a given basic need.³

Figure 14.3 illustrates how the idealized vision of Figure 14.2 can be modified as one tries to get practical. Depending on the circumstances, one might simply have a single premium (panel A)

³Economists have a technical concept of a public good, whose benefits are available to the public at large. A’s enjoyment of the national parks, for example, is not diminished by B and C also enjoying them (at least up to a given point of congestion). Thus their individual utilities can be summed in reaching society’s valuation of the parks. In the same way, many members of society are in fact willing to pay to reduce the incidence of malnutrition and disease among poor children (and poor people generally). A society’s total willingness to pay, under this concept, would be the sum of those of all that society’s members, some of whom, of course, could have zero willingness to pay. Dealing with basic needs via public sector actions as against (or in addition to) private charity is motivated by the fact that many people’s willingness to pay is very likely to be contingent on others also paying. They are willing to pay as long as others do also. We present this discussion of public goods as a link to economic theory. However, the basic needs approach can alternatively be thought of as simply reflecting a country’s policy, without seeking deeper roots for its justification.

applying to all basic needs improvements up to a point. Or one could simply distinguish between two (panel B), or three (panel C) levels, reflecting declining premia as needs are more fully met.

Figure 14.3



We feel that it is worthwhile for people to think in these terms, because doing so really helps them to understand their own values. Most people instinctively respond positively to the question, “Should food be exempted from a sales or value added tax?” Yet they tend to modify that view when they think of expensive meals in luxury restaurants, or gourmet foods bought in upscale stores. Many would end up preferring to tax most foods, and to explicitly, subsidize a few items (rice, beans, fresh vegetables, milk) that are important or valuable components of the diets of the poor. Trying to quantify basic needs according to an index gets people to think seriously about details such as this, and thus ends up with a pattern of premia that better reflects the society’s preferences and values.

However, it is certainly possible to implement a basic needs approach without the concept of an index. Thus one can be willing to incur greater costs (say, up to 50% above the national average) to bring about good results in primary schools in poor neighborhoods. Or one could simply not consider as costs the standard amounts spent giving prenatal care to poor mothers, or necessary shots and vaccines for poor children.

The big picture, so far as the basic needs framework is concerned, is that most societies are not ready to give the tuition money to the parents, and then let them choose to spend it on something other than educating their children. It is exactly similar, of course, for societies’ outlays on medical care, public housing and nutrition-oriented programs. In short, most societies are paternalistic in the way they provide and distribute public services. It is this element that points to a system built on basic needs externalities rather than distributional weights.

14.5 Basic Needs Externalities (Type B) Linked to Income

The gap between the basic needs approach and that of distributional weights may be substantial at a philosophical level, but may be quite easy to bridge at a practical level. The bridge consists of recognizing that individuals’ or families’ basic needs are progressively better met as one moves from the first to the second, then from the second to the third, then from the third to the

fourth deciles in the income distribution. Furthermore, it is often the case that a project will have the effect of actually lifting significant numbers of families to higher income levels in this fashion. This is quite commonly true for projects that involve incorporating workers into the so-called formal or modern sector of the economy, when otherwise those workers would be in the much lower-paid informal or traditional sector. When workers make this sort of transition their family incomes may jump, say from the first to the third decile. Quite rationally, then, and without any particular government or other external stimulus, the families will move to a better diet, take better medical precautions, fix the roof or windows or floors of their home, and raise the school-leaving age and grade of their kids. In short, they move forward in better meeting all four categories of basic needs.

One simple but also quite crude way of incorporating such considerations into a cost-benefit framework would be to assign a premium of, say, 40% to extra income within the first decile, or 30% to extra income within the second decile, of 20% to extra income within the third, and of 10% to extra income within the fourth decile. This could certainly be justified on basic needs grounds, but the analyst would find it hard to answer the question of precisely what is being paid for.

A better approach would be to operate with the average family budgets (in the project's region) of people in the successive deciles of the income distribution. Then, at least, one could detail how much more they are spending on food, housing, medical care, etc., and assign basic needs premia to these added expenditures. It would be still better to get into the specifics of what these added expenditures typically go to buy, and assign greater premia, say, to potable water than to curtains, and greater premia to extending the school-leaving age of the kids than to making extra trips back to the family's native village.

Sometimes the assignment of a basic needs premium to a particular item will be straightforward. For example, installing running water and plumbing in a house might warrant a premium equal to all or nearly all of its standard full costs. But other things might be more tricky to value. For example, in most countries public education is free, at least up to a certain grade level. The fact

that it is free is already a reflection of the society's willingness to pay, and keeping the kids in school longer may as a result not include any obvious extra educational expenditures in the family budget. Yet one might want to recognize a basic needs externality in the case where a new job in the formal sector causes a family's children to stay in school longer.

To illustrate, consider a case where a formal sector project is expected to lift 1,000 families from the first to the third deciles of income. We do not know who they are at the moment of analyzing the projects. So we go to a recent census or sample survey in order to find the distribution of children of households in each decile. We should at least be able to get what fraction of each decile's kids are in school at each age. So 1,000 families in the first decile would have 20 kids in the 9th grade, while 1,000 in the 3rd decile might have 50 kids in that grade. Making such calculations across all grades, one could estimate ΔN_g , the increase in the number of kids in grade g that we can expect as a consequence of the income improvement of the 1,000 families. We should also be able to estimate the approximate cost (borne by the state) of a student year at each grade level. If we call this cost C_g , we can then think of a basic needs premium that should apply to poor children reaching that grade level. That premium could be a general one Π^* , in which case the total education externality would be $\Pi^* \sum C_g \Delta N_g$. Or it could be a premium Π_g that varies with grade level, in which case the total education externality would be $\sum \Pi_g C_g \Delta N_g$. This number, in turn, need not necessarily be calculated for each project, but may simply serve as one component of a broad income premium that applies to the transition from the first to the third decile of the income distribution.

Appendix 14A

Distributive Weights versus Basic Needs Externality

The third postulate of underlying principles of applied welfare economics is that a dollar is valued at a dollar regardless of whether the benefit of the dollar accrues to a demander or a supplier, or to a high-income or a low-income individual. However, an extra dollar given to a very poor person will most likely increase that person's welfare more than that would a dollar be given to a very rich person because the marginal utility of income for the former is much higher than the latter. The analysis in project evaluation is therefore going beyond economic efficiency to determine which project will increase welfare by taking into account who receives the benefits and who pays the costs on equity ground. As pointed in this chapter, two different approaches -- distributed weights and basic needs externality -- have been undertaken to address this issues and they are explained below.

The distributed weights approach is to use weights to entail multiplication of the net welfare gains or net welfare losses of particular groups by specific factors. Most of the literature has focused on income and/wealth as the criterion, that is to assign different weights to incomes (and expenses) received (and expended) by different income groups in the stakeholder analysis of a project. The presumption is that the higher the income of an individual (or spending unit), the lower will be the distributional weight to be applied in order to reflect the lower marginal utility of an extra dollar to a rich man than that of the same dollar to a poor man. That is to ensure that a project's impact on welfare of the society is truly reflected in changes in incomes (or expenses) received (or paid) by individuals affected by the project.

The above notion is based on the concept of diminishing marginal utility of consumption. The more one individual consumes a particular good the less utility he gets by consuming additional unit of that good. The same logic applies to the general consumption a person consumes. Since the difference between consumption and income is savings, at margin the marginal utility of a dollar saved should be the same as the marginal utility of a dollar consumed. Thus, the marginal

utility of one dollar of income should be equal to the marginal utility of one dollar spent on consumption.

Suppose that the marginal utility of income for a specific income group, k , at the income level of Y_k that has a per capita consumption level of C_k can be expressed as:

$$MU_k = C_k^{-n} = Y_k^{-n}$$

where n stands for a utility parameter that is equal to or greater than zero. This implies that the marginal utility of income (or consumption) declines as income (or consumption) increases. The distributional weights assigned for the k th income group in society (d_k) can then be calculated by the ratio of the marginal utility of income (or consumption) of this group to the marginal utility of income (or consumption) for the average income level of the society:

$$d_k = MU_k/MU = (Y/Y_k)^n$$

where Y stands for the average per capita income in society.

Presumably, d is determined by the relative income level of each income group to the average income level in society as a whole (Y/Y_k) as well as the utility parameter (n). For illustrative purposes, suppose a beneficiary of a project is in the income group at annual income of \$1,000 while the national average income is \$2,000. The distributed weight for this beneficiary would be:

$$d = (2000/1000)^n = 2^n$$

The magnitude of d also depends on the value of n . If $n = 0.5$, then the beneficiary with annual income of \$1,000 will have the benefits of one dollar measured by a factor of 1.41. Another beneficiary with much lower annual income at \$500 will have the benefits of each dollar weighted by a factor of 2.00. On the other hand, for a beneficiary with a highly skilled worker

whose annual income is \$5,000, the benefits of an extra dollar generated from this project will be measured by a factor 0.63. Therefore, the smaller the income level of a specific income group, the greater the distributed weight is assigned to the additional welfare gain received by the group and vice versa.

In the case of the utility parameter, if $n = 0$, all d are equal to 1. This implies that one extra dollar received by any income groups of the society will be valued equally as a dollar. If $n = 1$, d will be assigned as the ratio of the average per capita income in society to the per capita income of the income group k . If $n = 2$, d is equal to power 2 of the above relative income ratio. This implies that a drastic declining marginal utility of income in society will be prevailing in society. The magnitudes of distributional weights are therefore dependent upon the perception of the government, policy makers or project analysts. Some people are inclined to link it to the existing progressive income tax schedule which, to some extent, reflects the marginal value of income to citizens or taxpayers.

Despite theoretical justification for practical applications, a great deal of difficulty is found that there is little basis for consensus concerning the underlying economic and noneconomic values involved in determining the distributed weights associated with income of individuals or families, especially we don't know what types of goods or services are purchased for consumption. The government or project analysts will have a hard time revealing the true preference scheme of individuals affected by the project in question. This will not be the case for the basic needs externality approach. As the weighting system can produce very wide disparities in weights for the rich and the poor, the ultimate selection from alternative investments can be swung from one option to another purely pending upon the weights being applied. However, some economists still prefer to use a rough justice for the weight scheme than not to use any justice at all because of concerns regarding diminishing marginal utility of income.⁴

⁴ See, e.g., Little, I.M.D. and Mirrlees, *Project Appraisal and Planning for Developing Countries*, London: Heinemann Educational Books Ltd, (1974); Squire, L. and van der Tak H., *Economic Analysis of Projects*, Baltimore: John Hopkins University, (1975); Schwartz, H. and Berney, R., *Social and Economic Dimensions of Project Evaluation*, Inter-American Development Bank, Washington D.C., (1977); Johansson-Stenman, O.,

The second approach, basic needs externalities, is based on the idea that citizens and taxpayers look for specific and concrete results when public funds are channeled into “helping others”.⁵ They are not interested in having their money used to gratify the recipients; instead they want to see it used in such a way as to advance the welfare of the recipients when they perceive that welfare. They argue that to consider social concerns for less fortunate members of society, an additional welfare can be accounted for if better educated, better care medically, better fed nutrient, and better housed are provided to these members. It is the altruism that is more closely linked to the basic needs of individuals rather than to their self-perception of their welfare.

Conceptually, the basic needs externalities of a project can be measured by setting a cutoff level above which no basic needs externality is deemed to exist as well as a maximum amount of inefficiency that the government or policy makers are willing to accept. First, cutoff levels for the attribution of any basic needs externality will be the typical consumption level of a particular percentile of the distribution of family, which is presumably to vary with the type of basic needs and the country in question. Second, in practice the government, policy makers or project analysts would have to decide that for the lowest percentiles of households, a basic needs externality of 30%, for example, of the normal cost of additional nutrients would be assigned. This percentage would decline to zero at the cutoff point. Thirty percent in this case is the maximum allowable externality that is also the maximum amount of excess cost the society would be accepting some inefficiency for meeting basic needs. This acceptance, presumably influenced by economic situations and the government objectives, would be tempered by the placing of explicit and conscious limits on the extra costs to be incurred on this account.

It is important to point out that the basic needs externality preserves the third postulate of principles underlying applied welfare economics. The additional positive externality is measured

“Distributional Weights in Cost-Benefit Analysis – Should we Forget about Them?”, *Land Economics*, Vol. 81, No. 3, (August 2005).

and assigned to the disadvantaged members of society according to the government or policy makers because the improvement of their education, health, nutrition and housing takes place and they are placed clearly alongside other externalities like air and water pollution, traffic congestion, etc.⁶ This is fitted well as part of distortions into the framework of $\sum D_i \Delta X_i$ in the tradition of applied welfare economics. On the other hand, the use of distributed weights entails the rejection of the third postulate of applied welfare economics. The acceptance or rejection of an alternative investment option may hinge on subjective choice of distributed weights assigned to incomes in society by bureaucracies or project analysts.

⁵ See Harberger, A.C., "On the Use of Distributional Weights in Social Cost-Benefit Analysis", *Journal of political Economy*, Vol. 86, No. 2, (1978); Harberger, A.C., "Basic needs versus distributional weights in cost-benefit Analysis", *Economic Development and Cultural Change*, (1984).

⁶ Harberger, A.C., "Reflections on Social Project Evaluation", Paper prepared for *Pioneers in Development*, Vol. II, Washington D.C.: World Bank, (1985).

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 15:**

COST-EFFECTIVENESS AND COST-UTILITY ANALYSIS

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ABSTRACT

The capital expenditure appraisal process has so far been presented in the framework of a cost benefit analysis where all benefits and costs are expressed in monetary values. However, many projects or programs undertaken by governments produce benefits that may be considered to be highly desirable but whose quantification in monetary terms is difficult if not impossible. Common examples of such projects are the provision of elementary school education, improvements in the provision of health care services, investment in public security and the administration of justice. In such cases, a full cost benefit analysis may not be feasible for each individual project or program but a cost-effectiveness analysis (CEA) can be carried out. Such an analysis measures the quantities of benefits generated in terms of the number of units of the items produced, but no attempt is made to convert these into monetary values. This chapter outlines a methodology for conducting cost effectiveness analysis and discusses its usefulness and its limitations. Further extensions of cost effectiveness are made into topics of cost utility analysis, and the limitations of cost effectiveness.

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CHAPTER 15

COST-EFFECTIVENESS AND COST-UTILITY ANALYSIS

15.1 Introduction

The capital expenditure appraisal process has so far been presented in the framework of a cost benefit analysis where all benefits and costs are expressed in monetary values. However, many projects or programs undertaken by governments produce benefits that may be considered to be highly desirable but whose quantification in monetary terms is difficult if not impossible. Common examples of such projects are the provision of elementary school education, improvements in the provision of health care services, investment in public security and the administration of justice. In such cases, a full cost benefit analysis may not be feasible for each individual project or program but a cost-effectiveness analysis (CEA) can be carried out. Such an analysis measures the quantities of benefits generated in terms of the number of units of the items produced, but no attempt is made to convert these into monetary values.

Cost-effectiveness analysis can be very useful at ranking the various activities that could be undertaken by a government department when the alternatives address a common set of objectives. For example, what is the most cost-effective way to generate electricity? Once the spending priorities are defined between the broad functions of government, the scarce budget funds can be allocated among projects within each of these functional areas based on the results of a cost-effectiveness analysis. Projects with a lower priority and smaller positive outcome are often shifted to the next budget period, when they can be considered again along with the other options available at that time.

Section 15.2 lays out the concepts of cost-effectiveness. Section 15.3 discusses the alternative ways of conducting the cost-effectiveness analysis, as well as its applications and limitations. Section 15.4 describes the general methodology for using cost-utility analysis. Sections 15.5 and 15.6 present the practical use of cost-utility analysis to education and

health projects, respectively. Conclusions are presented in the final section.

15.2 Cost-Effectiveness Analysis

When project benefits cannot be quantified in monetary terms, one can nonetheless choose among the alternative options based on the one that achieves a given outcome at least cost. A standard cost-effectiveness analysis in fact involves a series of steps similar to those of a cost-benefit analysis. The main difference is that the outcomes of the project are measured in physical units rather than be given monetary values. The focus is therefore on measuring the costs of the alternatives.

When a project or program lasts for several years, it is important to include all relevant capital and operating costs over the project's life in the calculation. Capital costs include expenditures on machinery, equipment and structure such as schools, hospitals and clinics, equipment, vehicles, etc. Operating or recurring costs include office supplies, drugs, utilities, wages and salaries of teachers, doctors, nurses and other staff. The cost-effectiveness of the project should be calculated by dividing the present value of total costs of the option by the present value of a non-monetary quantitative measure of the benefits it generates. The ratio is an estimate of the amount of costs incurred to achieve a unit of the outcome from each of the alternative options under consideration. For example, what are the costs (expressed in real dollars) of adding a year to a person's expected life when assessing different healthcare interventions?

The analysis does not attempt to measure benefits in monetary terms, it is rather to find the least-cost option to achieve a desired quantitative outcome. The costs should be measured at their resource costs in the economic analysis. They should include not only direct costs but also indirect and intangible costs. For example, in evaluating the impacts of alternative higher education proposals one must include the forgone earnings of the individuals while they are attending schools as part of the costs of obtaining a higher education in addition to attendance fees, transportation costs and other project costs. In a project delivering medical treatment, the time patients devote to waiting or traveling to hospitals or clinics should also

be counted as a component of project costs.

15.2.1 Measurement

Cost-effectiveness analysis first computes cost-effectiveness ratios for different alternatives, and aims at choosing the most efficient option by comparing the resulting ratios. The economic analysis, involves the comparison of the economic cost per unit of the outcomes for two or more alternatives in order to achieve the socially desired outcome. To the extent that these ratios focus on only one dimension of projects benefits, the analysis runs the risk of neglecting other important dimensions.

There are two alternative ways of computing cost-effectiveness (CE) ratios. Both involve the measurement of benefits in some kind of quantifiable manner, e.g., lives extended, schooling-years increased, additional water consumed. One way of computing the effectiveness is to estimate a ratio of costs to its benefit, for example, dollars per school seat. If there are a number of alternative options to providing schooling, then the costs of each alternative (C_i) are divided by the benefits (E_i):¹

$$CE_i = \frac{C_i}{E_i} \quad (15.1)$$

This ratio can be interpreted as the average cost for the i th option of a project per unit of effectiveness. According to this criterion, projects with the lowest ratios are preferred.

Suppose that a section of rural road requires a surface renovation, but it is not clear how much traffic will eventually pass through this road and what kind of surface dressing would be technically optimal: single-course surface dressing (A), raked-in surface dressing (B), and double-course dressing (C). If no significant change in traffic usage of this road segment is expected, a cost-effectiveness analysis can be employed in the selection among the mutually exclusive road surface dressings. Suppose that dressing A has expected life of 6 years, dressing B is expected to last for 8 years, and dressing C for 10 years. The costs of

¹ Boardman, A.E., Greenberg, D.H., Vining, A.R., and weimer, D.L., *Cost-Benefit Analysis: Concepts and Practice*, 2nd Edition, Prentice Hall, (2001).

each alternative are such that dressing A would cost \$14,000 per km of construction, B would cost \$21,000 per km, and C would cost \$28,000 per km. Table 15.1 presents the cost-effectiveness ratios for each road surface dressing.

Table 15.1
Average Cost-Effectiveness Ratios for Mutually Exclusive Types
of Road Surface Dressing

Options	Type of Surface	Construction Cost (dollars per km)	Expected Life (years)	CE Ratio	Ranking
A	Single-Course Surface Dressing	14,000	6	2,333	1
B	Racked-in Surface Dressing	21,000	8	2,625	3
C	Double-Course Dressing	25,000	10	2,500	2

In this example, the computed CE ratios mean that for a year of service, the average per-kilometer cost is lowest for single-course surface dressing A at \$2,333 per km. Alternative B is the most expensive method of road surfacing. Alternative C is preferred to B, but A is still preferred to C. The optimal choice of the road surface under cost-effectiveness analysis is, therefore, single-course surface dressing.

An alternative way of measuring cost-effectiveness ratios is to compute the effectiveness (E_i) in terms of its cost (C_i). This EC ratio could be thought of as the average effectiveness produced by a project per unit of cost:

$$EC_i = \frac{E_i}{C_i} \quad (15.2)$$

This ratio presumes that all the alternatives in question have non-negative benefits (E_i). Once the benefits and costs are defined and estimated, the procedure of ranking alternative projects would be to simply choose the alternative with the highest ratio.

For illustration, we take an example in the agriculture sector. The choice of animal feed is based on the availability of particular feed, its costs and nutrient content. The exercise is to maximize the animal growth measured in kilograms, per dollar spent on feed. The nutrient

contribution of a particular feed to the process of growth of animal is measured in amount of nutrient per unit of feed. A feed with a richer content is preferred to a type with lower nutrition content. For each animal type, there are detailed programs stipulating a minimum daily requirement of nutrition components for a healthy and rapid weight growth. The alternatives are such that the necessary amount of daily nutrition component, for example protein, could be secured through either an expensive fish-meal or by using cheaper sunflower oilcake but in a larger volume.

With a given availability of certain types of raw feed ingredients and their costs, the choice is then to combine them into a feed mix that would satisfy the minimum daily nutrition content at the lowest cost. Table 15.2 lists an array of possible ingredients available for production of animal feed. Their costs and nutrition effectiveness, measured in terms of percentage of minimum daily requirement for protein, are also stated. The task of the analyst is to rank the alternative ingredients according to their cost effectiveness in a final feed mix.

Table 15.2
Average Effectiveness-to-Cost Ratios for Animal Feed Ingredients

Options	Ingredient	Cost (\$000s/ton)	Protein Content (proportion by weight)	EC Ratio	Ranking
A	Maize By-Products	0.8	0.11	0.138	1
B	Corn Silage	0.4	0.03	0.075	6
C	Wheaten Bran	0.9	0.09	0.100	2
D	Molasses	0.5	0.04	0.080	5
E	Sorghum	0.8	0.07	0.088	4
F	Sunflower Oilcake	2.5	0.15	0.060	8
G	Soya Oilcake	2.8	0.25	0.089	3
H	Fish Meal	4.7	0.35	0.074	7

This table shows that option A is the most cost effective animal feed (the one with highest EC ratio). It should be noted that the nutrient content of different ingredients does not vary much over time but their prices fluctuate widely. This implies that the ranking of the options will very likely change over time.

15.2.2 Marginal Cost-Effectiveness Ratio

When we evaluate several alternative options to the existing situation, we need to compute incremental or marginal cost-effectiveness ratios. In the computation, the numerator refers to the difference between the cost of the new and the existing alternatives (i.e., C_i and C_0) while the denominator shows the difference between the effectiveness of the new and the existing alternatives (i.e., E_i and E_0):

$$\text{Marginal CE}_i = \frac{C_i - C_0}{E_i - E_0} \quad (15.3)$$

This ratio represents the incremental cost per unit of effectiveness. When there are several alternatives available, the marginal cost-effectiveness ratio should be the one used to rank the new measures versus the existing situation.

An illustration of this ratio is given below with a hypothetical example of the prevention of deaths from traffic accidents. The ultimate goal is to minimize the number of traffic accidents on the roads per year. Assume that there has been a program (A) in place that has already reduced the number of accidents over past years. Now, an additional reduction in accidents and resulting fatalities is desired, and this could be achieved in a number of alternative ways. First, the system of tracking and prosecution of road speeder could be enhanced, and this will involve more police officers on the roads (B). Second alternative is to improve the roads condition, and to equip the roads with additional safety signs and markings (C). Third way is to run a continuous public awareness campaign (D).

Let's assume that the existing policy, which has been in place for years, costs \$20.0 million and it effectively prevents numerous accidents as well as some 500 related deaths a year. Also assume that the alternative B would prevent another 100 deaths and cost \$5.5 million per year. Alternative C is estimated to cost \$11.5 million and result in additional reduction of 500 fatalities every year. The third policy, alternative D, may reduce the road casualties by additional 85 cases, and its costs are projected to be about \$5.0 million a year. Table 15.3 illustrates the computation of marginal cost-effectiveness ratios and their ranking. The cost-effectiveness ratio for options B, C, and D are marginal, since they represent an incremental

expansion of the existing prevention system.

Table 15.3
Marginal Cost-Effectiveness Ratios in Prevention of Traffic Fatalities

Options	Policy Measures	Total Lives Saved	Total Cost (\$million)	Marginal CE Ratios (\$)	Ranking
A	Existing	500	20.00	40,000	n/a
B	Existing plus Enforcement	600	25.50	55,000	2
C	Existing plus Road Safety	1000	31.50	23,000	1
D	Existing plus Public Campaign	585	25.00	58,824	3

The average cost of a life saved under the existing program is \$40,000 per year, excluding all other prevented damages and health loss from traffic accidents. The marginal effectiveness of the proposed three policy options are such that the road safety improvement (C) ranks the first, then the law enforcement (B), and finally the public campaign alternative (D). Note that, at the margin, only option C is more cost-effective than the existing system, since the marginal cost under measure C of lives saved is only \$23,000 as compared to the cost of \$40,000 under the existing system.

If a budget constraint is introduced at, say \$6.0 million, then the ranking of the three alternatives will change. Option C, whilst the most efficient, can not be undertaken now because it exceeds the available budget. Then the selection compares alternative B and D in terms of being the most efficient user of funds. The most efficient option becomes alternative B, better enforcement, which costs \$5.5 million and saves a total of 100 people. The options of road safety (C) and public campaign (D) are likely to be preserved for a future budget period, when funds become available.

15.2.3 Costs Measured in Present Value

The costs incurred in interventions or alternative options may involve capital or operating

expenditures that are spread over many years. Capital projects usually have large investment outlays at the beginning and then recurrent costs and their benefits are spread over many subsequent years. The costs and benefits should be both discounted to a common time period in order to make a comparison of alternative options. Because the benefits are measured in physical units, the effectiveness in quantity should be discounted by the same rate as the costs. Thus, the proper cost-effectiveness ratio for the i th option can be expressed as follows:

$$CE_i = \frac{\text{PV of Costs}_i}{\text{PV of Effectiveness}_i} \quad (15.4)$$

After the cost-effectiveness ratios are computed for each of the alternative options, the analyst can rank the alternatives and take a decision.

The question of what is the appropriate discount rate to use in the social projects or programs is often raised, especially in the health projects. This will be addressed later.

15.2.4 Limitations of the Analytical Technique

There are some concerns of using cost-effectiveness analysis. These issues are discussed below.

a) Does not Measure Willingness to Pay

Cost-effectiveness ratios are a poor measure of consumers' willingness to pay. For example, most of the taxpayers would probably be happy to pay for the prevention of an additional number of deaths being caused by traffic accidents. But what is the willingness to pay for the prevention of deaths of drug addicts? Furthermore, the number of addicts treated or the number of lives saved through the treatment of drug addicts generally stands for the effectiveness of a medical intervention. However, it may not be the best measure for which people are willing to pay. In the case of a program to reduce drug addiction will both save lives and also reduce the incidence of crime. It is likely the crime reduction impact that the taxpayers are willing to pay most for. Faced with this kind of situation, the analyst must make sure that the link is made to the ultimate impact valuable for which people are willing to pay for to obtain an accurate assessment of the relative worth of the proposed

interventions.

b) Excludes Some External Benefits

Cost-effectiveness analysis excludes most externalities on the benefit side. It looks only at a single benefit and all other benefits are essentially ignored. For example, an improvement in education will not only increase life-time earnings of the students but also likely to contribute to a reduction in the rates of unemployment and crime. In healthcare, there are external benefits due to such treatments as the vaccination of children because the disease is not spread to others. The analyst undertaking the evaluation should be careful not to exclude important benefits arising from a particular project.

c) Excludes Some External Costs

As was pointed out earlier, while computing the cost-effectiveness ratio for a particular project, attention should also be paid to the treatment of social costs beyond direct financial costs. Different types of projects often have some of the costs in non-monetary value, such as coping costs, enforcement costs, regulatory costs, compliance costs, and forgone earnings. The economic cost-effectiveness analysis carried out for such projects must account for all costs, measured at the resource costs rather than the financial costs of goods and services.

d) Does Not Account for Scale of Project

Scale differences may distort the choice of an “optimal” decision when a strict cost-effectiveness analysis is employed. A project with smaller size but higher efficiency level may get accepted, while another project may provide more quantity of output at a reasonable cost. A complete cost benefit analysis does not have this problem because the present value of net benefits already accounts for the difference in size among alternative projects.

15.3 Constraints in the Level of Efficiency and Budget

This section deals with the scale problem in cost-effectiveness analysis by introducing a constraint, either on the maximum acceptable cost or on the minimum acceptable level of

effectiveness.²

a) *Minimum Level of Effectiveness*

When the objective is to achieve a minimum level of effectiveness, then the analysis simply looks for the lowest cost solution (C_i) ensuring the minimum effectiveness level. That is,

$$\begin{aligned} &\text{Minimize } C_i \\ &\text{Subject to } E_i \geq \bar{E} \end{aligned} \tag{15.5}$$

This approach assumes that there is little value in exceeding the target effectiveness level. Any additional units of effectiveness beyond \bar{E} are not valued in the analysis, i.e., only the total cost is minimized but not the cost per unit. This approach results in the selection of the cheapest alternative that satisfies the minimum effectiveness criterion, even if there are other alternatives that offer more units of effectiveness at lower per unit cost. This rule generally favors projects with low total cost. Often, the lowest total cost does not constitute the best project.

With the criterion (15.5), additional units of effectiveness may be still worth something but not accounted for. Instead of selecting the cheapest alternative in terms of total cost, the decision makers may like to select an alternative with the lowest per unit cost. Then, an adjusted project selection criterion is used in which the minimum CE_i ratio is chosen such that the effectiveness is greater than the specified threshold level:

$$\begin{aligned} &\text{Minimize } CE_i \\ &\text{Subject to } E_i \geq \bar{E} \end{aligned} \tag{15.6}$$

This new criterion (15.6) ensures a higher effectiveness level and likely to result in higher costs than the unconstrained cost-effectiveness ratio (15.5). The project selected under this rule is generally larger in size and more cost efficient.

² Boardman, A.E., Greenberg, D.H., Vining, A.R., and weimer, D.L., *Cost-Benefit Analysis: Concepts and Practice*, Second Edition, Prentice Hall, (2001).

b) Maximum Budget Constraint

The other side of the same coin is the problem of maximizing the level of effectiveness subject to a budget constraint. If the budget is fixed then the intuitive solution is to choose an alternative that generates the most benefits. That is,

$$\begin{aligned} &\text{Maximize } E_i \\ &\text{Subject to } C_i \leq \bar{C} \end{aligned} \tag{15.7}$$

Under this rule, any cost savings beyond \bar{C} are not accounted for, and selection only looks for maximization of total efficiency, but not efficiency per dollar of spending, i.e., incremental cost savings are ignored. This fails to make a sensible choice in a situation when two alternatives achieve exactly the same total efficiency but have different costs, both below or equal to the minimum cost \bar{C} . Because both alternatives have costs below the budget limit, and both result in the same total efficiency, then the two alternatives would be ranked the same.

An alternative solution to this problem is to do the project selection on the basis of the lowest CE_i ratio, which fits the budget constraint:

$$\begin{aligned} &\text{Minimize } CE_i \\ &\text{Subject to } C_i \leq \bar{C} \end{aligned} \tag{15.8}$$

This rule (15.8) now effectively places some value on incremental cost savings. It selects the most cost-efficient alternative, subject to a budget constraint.

15.4 Application: Olifants-Sand Water Transfer Scheme³

The growth in water demand over time by the various water users in Polokwane, Capricorn District, and Sekhukhune Cross Border District in South Africa is rapidly using up all the available water resources. Six groups of water users have been identified including, the

³ This section is extracted from the “Capital Project Selection Handbook for Department of Education”,

Provincial capital area, Polokwane, Lebalelo Water User Association (WUA), the mining companies, smaller town centers, irrigation demands, and the rural communities.⁴

The Olifants-Sand River Water Transfer Scheme (OSWTS), including the building of the Rooipoort dam, was proposed as a major new source of potable water for the region. Three alternative strategies are under consideration:

- A. Raise the existing Flag Boshielo dam by 5 meters but do not build the Rooipoort dam.
- B. Construct the Rooipoort dam but do not raise the Flag Boshielo dam.
- C. Construct Rooipoort dam and also raise the Flag Boshielo dam by 5 meters.

Another important and related issue is the scale of the Rooipoort dam. Technically, two alternative sites are available: upstream site (smaller reservoir volume), and downstream site (larger reservoir volume). Both upstream and downstream sites have 3 possible wall heights (full supply levels, FSL), resulting in different capacity of the reservoir. The upstream dam location has three possible levels of the wall height: FSL724 (shortest), FSL728 (medium), and FSL731 (highest). The downstream site also has three alternative levels of the wall height: FSL720 (shortest), FSL725 (medium), and FSL731 (highest). Since only one dam wall will be built, all six options are mutually exclusive alternatives. The investment costs for each of the six options are different. Needless to say, each of the six scale alternatives results in a different capacity volume for the dam reservoir and different amounts of water available for supply.⁵

An amount of water shortage can be calculated from the amount of available water supply less the total bulk water demand. Table 15.4 summarizes the total water shortages under

Limpopo Province, Republic of South Africa, (September 2004).

⁴ Shand, N., "Olifants-Sand Water Transfer Scheme: Feasibility of Further Phases", Interim Report, Prepared by Ninham Shand for the Department of Water Affairs and Forestry, Government of the Northern Province, P B500/00/2499, (2001).

⁵ Details can be found in Cambridge Resources International, Inc., "Evaluation of the Olifants-Sand Water Transfer Scheme in the Limpopo Province of South Africa", report prepared for the Department of Finance and Economic Development, Government of Government Province, South Africa, (January 2003).

alternative development strategies and project scales over the period 2002-2020 in terms of present value of quantity of the shortage.⁶ The amount of water deficit, expressed in million cubic meters, is discounted to year 2002, the starting point of the analysis.

Table 15.4 Present Value of Water Shortages under Alternative Development Strategies and Project Scales (million m³ in 2002)

	Rooipoort Site	Upstream			Downstream		
	Height of Rooipoort Wall	FSL724	FSL728	FSL731	FSL720	FSL725	FSL731
A	Flag Boshielo+5m (Rooipoort is not built)	85.7	85.7	85.7	85.7	85.7	85.7
B	Rooipoort (Flag Boshielo is not raised)	56.4	31.9	19.7	56.4	28.7	15.6
C	Flag Boshielo+5m and Rooipoort	12.2	3.6	1.7	12.2	2.8	1.7

The highest amount of water shortage is about 85 million m³ when only Flag Boshielo is raised and Rooipoort is never built. The strategy that includes both raising the Flag Boshielo and building the Rooipoort results in the lowest present value of water shortages of 1.7 million m³. If rule (15.5) were used to rank the three alternative water development strategies, then strategy A would be excluded from further evaluation since it does not provide enough water to users.

The analysis of such a project is to ensure the minimum cost effectiveness level of water supply, in terms of alleviating water shortage over years, i.e., rule (15.6) is employed. Thus, the criterion for selection of the best water development policy and scale of the projects is the level of efficiency of the project to provide certain “basic needs” to the region, which are essential for sustainable functioning of the economy. The CE_i ratios are therefore computed as the present value of all investment, operating and maintenance costs of each strategy and each scale of the project, divided by the present value of water delivered to bulk users under the corresponding alternative configuration of the OSWTS:

⁶ The discount rate used for both the costs and quantity of water shortage in this project was estimated at 11 percent real for South Africa. See Kuo, C.Y., Jenkins, G.P., and Mphahlete, M.B., “The Economic Opportunity Cost of Capital in South Africa”, *South African Journal of Economics*, Vol. 71:3, (September

$$\text{Marginal Financial Unit Cost of Water} = \frac{\text{PV}_{\text{Investment}} + \text{O \& M}}{\text{PV}_{\text{Quantity of Water Delivered}}} \quad (15.9)$$

The criterion represents the marginal financial unit cost of water delivered to bulk users. Table 15.5 shows the resulting water costs, expressed as the number of Rand per cubic meter of water, under the alternatives in question.

**Table 15.5 Marginal Financial Unit Cost of Water Delivered to Bulk Users
(Rand per m³ of water in 2002 Prices)**

	Rooipoort Site	Upstream			Downstream		
	Height of Rooipoort Wall	FSL724	FSL728	FSL731	FSL720	FSL725	FSL731
A	Flag Boshielo+5m (Rooipoort is not built)	1.47	1.47	1.47	1.47	1.47	1.47
B	Rooipoort (Flag Boshielo is not raised)	3.00	2.49	2.29	3.15	2.50	2.20
C	Flag Boshielo+5m and Rooipoort	2.17	2.06	2.05	2.26	2.10	2.04

We first determine which development strategy is worth pursuing. If a maximum acceptable amount of water shortage was set, then strategy A is not a viable option for economic development simply because it does not provide enough water to the users. With this condition, the analyst would then compare strategy B and C in terms of their CE ratios. Table 15.5 shows that strategy C is superior to strategy B at all scales of the project because the marginal cost of water under strategy C is lower. Therefore, strategy C is an “optimal” way of developing water resources. Finally, in choosing the wall height of the Rooipoort site, the design of the Rooipoort dam at downstream site with the highest, and the most expensive, dam wall (FSL731) has the lowest marginal financial cost of water at Rand 2.04 per m³ in 2002 prices.

We now turn to the economic evaluation of the OSWTS. The marginal economic unit cost of water is calculated as the sum of all the economic costs of the OSWTS divided by the total

quantity of water delivered to bulk users, all being expressed in present value:

$$\text{Marginal Economic Unit Cost of Water} = \frac{\text{PV} \left[\text{Economic Costs}_{\text{Investment+O\&M}} \right]}{\text{PV} \left[\text{Quantity of Water Delivered to Users} \right]}$$

This formula should be modified to include the impact of water deficit on the economy as follows:

$$\text{Marginal Economic Unit Cost of Water (R}_{2002} / \text{m}^3) = \frac{\text{PV} \left[\text{Economic Costs}_{\text{Investment+O\&M}} \right] + \text{PV} \left[\text{Economic Cost of Water Deficit} \right]}{\text{PV} \left[\text{Quantity of Water Delivered to Users} \right] + \text{PV} \left[\text{Quantity of Water Deficit} \right]} \quad (15.10)$$

Assuming the opportunity cost to the country of any water deficit to be 3.0 R/m³, then the opportunity cost of water deficit to the economy can be calculated by applying the value to each unit of water that is not delivered to the users. The highest opportunity cost would be incurred if strategy A were undertaken, which results in a massive water shortage as compared to the other two strategies.

Table 15.6 presents the marginal economic unit cost of water delivered to bulk users resulting from the different development strategies and scale of the project. It is interesting to note that if the cost of water shortages is not accounted for then strategy A has the lowest water cost per unit delivered to bulk users. However, when the economic cost of water deficit is considered at assumed 3.0 R/m³, strategy A results in the most expensive water cost as compared with the two other strategies. The conclusion from the economic cost effectiveness analysis of the Olifants-Sand Water Scheme is that the best development strategy is C, comprising the raising of Flag Boshielo dam and building Rooipoort dam at the wall height of FSL 731. The unit cost is the same at the upstream or downstream sites of the highest dam option.

Table 15.6
Marginal Economic Unit Cost of Water Delivered to Bulk Users
(Rand per m³ in 2002 Prices)

	Rooipoort Site	Upstream			Downstream		
	Height of Rooipoort Wall	FSL724	FSL728	FSL731	FSL720	FSL725	FSL731
A	Flag Boshielo+5m (Rooipoort is not built)	2.19	2.19	2.19	2.19	2.19	2.19
B	Rooipoort (Flag Boshielo is not raised)	3.40	2.43	2.07	3.53	2.39	1.95
C	Flag Boshielo+5m and Rooipoort	2.16	1.94	1.89	2.25	1.97	1.89

15.5 Cost-Utility Analysis

The cost-effectiveness analysis can be extended to more sophisticated and meaningful ways of measuring benefits. A quantitative measure may be made by constructing a composite index to account for more than one benefit of the project. This refers to a weighted cost-effectiveness analysis or cost-utility analysis (CUA). It could include some of the benefits excluded from cost-effectiveness analysis.

In the case of healthcare, the cost-utility analysis usually use either “quality-adjusted life-years” (QALY) or “disability-adjusted life-years” (DALY) as a measure of benefits. The QALY measure integrates two dimensions of health improvement: the additional years of life, and quality of life during these years. DALY, on the other hand, combines years-of-productive life saved and a measure reflecting the number of productive years saved but with a disability. Since there are both mortality and morbidity impacts, the total DALY effect will be more complicated by summing productive weighted years-of-life saved at different ages and years of temporary and chronic disability. On the basis of QALY or DALY per dollar spent, the decision-maker would choose the options with the highest ranking in terms of benefits. Hence, cost utility analysis attempts to include some of the benefits excluded from the pure cost-effectiveness analysis, moving it a step closer to a full cost benefit analysis.

The estimation of benefit in CEA is limited to a single measure of effectiveness. This simplification is often not acceptable and, instead, a cost-utility analysis is employed. In principle, CUA could be used with multiple outcomes but as the number of dimensions grows, the complexity of analysis also increases. CUA has been traditionally applied in education and health projects, combining improvements in both quantity and quality.

CUA is a natural extension of cost-effectiveness analysis, and the difference is really the accounting for the benefits of project. Cost-utility analysis forces the analyst to compile a composite index of outcomes, i.e., utility level as a measure of benefits. Each type of benefit (B_j) is assigned its relative importance, or weight (w_j), in the utility:

$$CU_i = \frac{C_i}{\left(\sum_{j=1}^n (B_j * w_j) \right)_i} \quad (15.11)$$

In constructing a weighted effectiveness index, the most delicate task is the assignment of relative weights, indicating the importance of a particular outcome compared to other benefits in the utility. When the weighting of the various benefits yields a controversial interpretation of the relative worth of the different outcomes, then the analyst should refer to opinions of experts, policymakers' preferences, and stakeholder views. These subjective opinions may be a useful indicator of what is the relative importance for each of the project's outcomes.

Note that the significance of weights is to rank the different outcomes relative to each other, using the same scale of measurement. It is not even necessary that the sum of all weights is equal to one, as long as the scale used across the different types of benefits is identical. Once the metric is chosen and outcomes are ranked relative to each other, the cost-utility analysis becomes very similar to cost effectiveness analysis. Likewise, the analyst can use either cost-utility ratios or utility-cost ratios to arrive at the same results.

Cost-utility analysis is frequently employed by policymakers in health, education, defense, security, and many other sectors. A typical case when CUA is a necessity is when a set of

alternative policy actions must be evaluated, each resulting in multiple outcomes and a cost-benefit analysis is not possible. A simple cost effectiveness analysis is also not appropriate because it ignores a host of important benefits.

15.6 Application of CUA in Education Projects

15.6.1 Nature of Education Projects

Acquiring an education can be viewed as a process of human capital formation. However, education projects may have many types of outcomes with benefits measurable in monetary and non-monetary terms. In broad categories, investment in education can generate various in-school and out-of-school benefits. In-school benefits cover gains in the efficiency of the education system, which may be intangible or difficult to quantify. In such cases, the production of education services involves decisions of how one can select from alternative investment strategies based on the lowest cost per unit of effectiveness.

Out-of-school benefits refer to improvement of earning capacity of the students and externalities that accrue to society at large beyond the project beneficiaries. It generally arises after the project's beneficiaries finish a course of study or training. The most obvious of such benefits is measured by the gain in productivity of the beneficiaries that is usually reflected in the change in the earnings of the individuals between the with and the without training situations.⁷ In evaluating an education project or program from society's point of view, the benefits will include the change in the gross-of-tax earnings including the value of the fringe benefits such as value of health insurance, vehicles, housing allowances and retirement benefits as a package. For example, in the case of evaluating a 4-year university program, the present value of net benefits can be calculated over 40 years after graduation as follows:⁸

⁷ See, e.g., Psacharopoulos, G., "Returns to Investment in Education: A Global Update", *World Development*, Vol. 22, No. 9, (1994); Belli, P., Khan, Q., and Psacharopoulos, G., "Assessing a Higher Education Project: a Mauritius Feasibility Study", *Applied Economics*, 31, (1999).

⁸ Belli, P., Anderson, J.R., Barnum, H.N., Dixon, J.A., and Tan, J.P., *Economic Analysis of Investment Operations: Analytical Tools and Practical Applications*, The World Bank, Washington D.C., (2001).

$$NPV = \sum_{t=4}^{t=43} \frac{(E_U - E_S)}{(1+i)^t} - \sum_{t=1}^{t=4} (E_S + C_u)_t (1+i)^t \quad (15.12)$$

where E_s and E_u refer to the earnings of secondary school and university graduates, respectively, C_u refers to annual cost of university education, i refers to discount rate, and t refers to time period. It should be noted that certain benefits such as crime reduction, social cohesion, income distribution, and charitable donation are intangible and difficult to incorporate in the evaluation. Nevertheless, earnings are widely used to measure returns to investment in education.

Having said that, a variety of educational benefits are recognized but cannot be measured in monetary terms. Cost-utility analysis is therefore a technique being used to help project selection given budget constraints.

15.6.2 Developing Priority Index for Construction of New Classrooms in Developing Countries

The task of typical education projects in developing countries is often to maximize the overall effectiveness of public expenditure on school infrastructure within a given amount of budget. This usually involves two main processes in capital investment appraisal: (a) selection of schools for construction of new classrooms and (b) allocation of funds between the construction of new classrooms and rehabilitation of the existing facilities.⁹ The approach is to employ a cost-utility analysis by first developing a weighted “priority index” (PI) that include all the important factors affecting the project selection and then accounting for costs in order to achieve the same objective at the least cost.

The priority index can include as many factors as the decision-makers need to cover in the

⁹ Cambridge Resources International, Inc., Capital Project selection: Handbook for Department of Education, paper prepared for Department of Education, Limpopo Provincial Government, Polokwane, South Africa, (September 2004).

allocation of funds across state or provincial schools. Presumably we would focus on the main factors identified by the educational authority. For simplicity, a weighted priority index can be constructed as follows:

$$PI = (\text{Infrastructure Adequacy Factors}) * (\text{Augmenting Adjustment}) \quad (15.13)$$

$$\text{Where: Infrastructure Adequacy Factors} = \left(\begin{array}{l} \text{Backlog of Class-Blocks} * \text{weight}_{\text{Backlog}} \\ \text{Excess Class Attendance} * \text{weight}_{\text{Excess}} \end{array} \right)$$

$$\text{Augmenting Adjustment} = 1 + \sum_{j=1}^n (\text{Augmenting Factor}_j * \text{weight}_j)$$

Infrastructure adequacy is the most crucial set of factors indicating the need for additional school infrastructure. There are two aspects of infrastructure adequacy: class-block backlog and the student-to-classroom ratio. Both indicators must be computed for all schools applying for additional buildings. In addition to the infrastructure adequacy, the decision-making process also considers a host of factors that help project selection. These factors could be grouped into the categories such as type of school (primary versus secondary), presence of support facilities, location of the school, and development priority factors.

The most important indicator of the need for additional capital funding is the infrastructure adequacy of schools as measured by the number of class-block backlogs and the excess of the learner-to-classroom over the target class size. If these two indicators are assumed to add up to unity, the issue becomes whether, and to what extent, having enough class-blocks to accommodate students is more important than having smaller sizes of the students in the classroom. For all intents and purposes, the former is assumed somewhat more important than the latter and thus the class-block backlogs are assigned having a weight of 0.7 and the excess of the student-to-classroom over the target class size has a weight of 0.3.

Suppose there are two primary school areas, A and B, with a respective population of 600 and 400 learners. If area A currently has 8 classrooms and area B has 3 classrooms, then their student-to-classroom ratios are 75 and 133 students per classroom. The class-block backlog is estimated as a number of additional buildings required, measured by a standard 4–

class block required at school in order to maintain the maximum acceptable class size. With the assumed target of 40 students per class in primary school, one can estimate the class-block backlog at 1.75 blocks for area A and also for area B.¹⁰ In other words, if schools A and B both have the same number of additional buildings required, but area B has a higher student-to-classroom ratio, then this area should be given more priority.¹¹

A composite index can be then estimated from these two indicators and associated weights assigned to them. The score of school-area A would be equal to 1.79 (= 1.75 backlogs * 0.7 + 1.875 excess ratio * 0.3). Similarly, the score of school-area B would be estimated as 2.22. As a result, the priority of school-area B is higher than the priority of school-area A, based on the two infrastructure adequacy factors. Such infrastructure adequacy composite score can be computed for all schools concerned and a ranking of all schools based on purely infrastructure adequacy can be made accordingly.

In addition to infrastructure adequacy factors, a number of additional aspects may be considered. These factors may include type of school, presence of support facilities, location of the school, and development priority. The objective is to develop an augmenting adjustment index, ranging from unity to an additional number, say, 1.75, to account for additional concerns by the educational authority and society as a whole. In other words, all augmenting factors could introduce an upward shift in the index up to a limit of 0.75 taking the infrastructure adequacy score as the base. Table 15.7, for example, presents a summary of a tentative priority scores among the four identified groups of augmenting factors. The actual weights could be further refined as needed.¹²

¹⁰ For school A, the backlog is estimated as 7 classrooms (= [600 students – (8 class-rooms * 40 students)] / 40 students-per-classroom), or 1.75 class-blocks. For school B, the same procedure yields 7 class-rooms (= [400 students – (3 class-rooms * 40 students)] / 40 students-per-classroom), or 1.75 class-blocks.

¹¹ The excess ratio of learner-to-classroom over the target class size is 1.875 for area A and 3.325 for area B. These figures are estimated as the ratio of (75 students-per-classroom / 40 students-per-classroom) and (133 students-per-classroom / 40 students-per-classroom), respectively.

¹² A positive augmentation factor for primary versus secondary schools could be based on the fact that generally the case that the rate of return from primary education is higher than for secondary education.

Table 15.7 Weights for Each of Augmenting Factors

1. Type of School	
Primary (P=0.25) or Secondary (S=0)	0 or 0.25
2. Support Facilities	
Water (N=0.08) or (Yes=0)	Max = 0.25
Toilets (N=0.08) or (Yes=0)	0 or 0.08
Electricity (N=0.04) or (Yes=0)	0 or 0.04
Fences (N=0.02) or (Yes=0)	0 or 0.02
Library (N=0.01) or (Yes=0)	0 or 0.01
Labs	
Primary (N=0.01) or (Yes=0)	0 or 0.01
Secondary (N=0.02) or (Yes=0)	0 or 0.02
3. Location of School	
Rural (R=0.20) or Urban (U=0)	0 or 0.20
4. Development Factors	
Expected Population Decline (N=0) or (Yes: -0.40 to 0)	Min = -0.40
Other Factors (N=0) or (Yes: 0 to 0.05)	0.00 to 0.05
Maximum Weight of Augmenting Factors	0.75

The weighted priority index is computed as the infrastructure adequacy score multiplied by the augmenting adjustment factor, ranging from 1.00 to 1.75. Suppose there are two schools C and D and their respective features are displayed as Table 15.8. The former is a secondary school with 550 students and 6 classrooms while the latter is a primary school with 629 students and also 6 classrooms. If the target class size is 40 students per class for the primary schools and 35 students for the secondary schools, the number of backlogs will be identical at 2.43 blocks for both schools. The excess ratio will also be the same at both schools at 2.63. As a result, both schools will end up with an identical infrastructure adequacy score of 2.49.

Let us further assume that school C is in urban area with presence of all basic support facilities, and school D is a school with none of the amenities. The augmenting factors weight for the first school will be zero because it is a secondary school in an urban area with all the basic support facilities such as toilets, water supply, fences, electricity, library, and laboratories. However, the weight for school D will be uplifted by a total of 0.69 points due to its inadequate facilities and other factors as shown in the last column of Table 15.8. Thus, its priority index becomes 4.20, which is equal to its infrastructure adequate score of 2.49

adjusted upward by additional 0.69 points. With the inclusion of the augmentation factors, school D has a higher priority than school C to receive an additional school block.

Table 15.8 Estimation of Priority Index

INFRASTRUCTURE ADEQUACY					
	Weight	School C	School D	School C	School D
Total Number of Learners		550	629		
Available Classrooms		6	6		
Learner-to-Classroom Ratio		92	105		
Class-blocks Backlog	0.70	2.43	2.43	1.70	1.70
Learner-to-Classroom Ratio/Target Size	0.30	2.63	2.63	0.79	0.79
Total Weight of Section	1.00		Total Section Score:	2.49	2.49
AUGMENTING FACTORS					
1. Type of School	0.25				
Primary (P) or Secondary (S)		S	P	0.00	0.25
2. Support Facilities	Max = 0.25				
Water	0.08	Y	N	0.00	0.08
Toilets	0.08	Y	N	0.00	0.08
Electricity	0.04	Y	N	0.00	0.04
Fences	0.02	Y	N	0.00	0.02
Library	0.01	Y	N	0.00	0.01
Labs		Y	N	0.00	0.01
Primary	0.01				
Secondary	0.02				
			Total Section Score:	0.00	0.24
3. Location of School	0.20				
Rural (R) or Urban (U)		U	R	0.00	0.20
4. Development Factors					
Expected Population Decline	-0.40	N	N	0.00	0.00
Other Factors	0.05	N	N	0.00	0.00
			Total Section Score:	0.00	0.00
Maximum Weight of Augmenting Factors	0.75		Total Augmenting Factors:	0.00	0.69
Maximum Possible Augmenting	1.75		Augmenting Adjustment:	1.00	1.69
PRIORITY INDEX AND RANKING					
			Priority Index:	2.49	4.20
			Ranking:	2	1

Since the weighted priority index reflects a number of objectives, the overall effectiveness of budget spending is maximized when the educational funds are forwarded to schools with the highest ranking. Because each additional building will alter the current priority index and ranking of schools, the ranking needs to be recalculated after each new addition of classrooms, changes in the type of school, or changes in the development priority factors. It is a multi-stage selection process to allocate the limited funds in the most efficient manner. This system of prioritization will ensure that the benefits are maximized from the

allocation of capital budget for the construction of new class-blocks.

One can further extend the analysis to incorporate the physical condition of these facilities and the rehabilitation costs required.¹³ In so doing, the priority for limited budget may become the choice between building a new class-blocks and rehabilitation of the existing facilities with a consideration of relative costs.

15.7 Application of CUA in Health Projects

15.7.1 Nature of Health Projects

There are many examples of market failures in the health sector. It is heavily regulated by governments. The health services are generally subsidized at least at the primary care level. In almost all situations in the field of health care patients do not pay a price or fee that reflects the opportunity costs of the resources employed. Knowledge and information between physicians and patients about sickness or disease is asymmetric. As a result, the supply and demand for the services is not negotiable or as well defined as other goods or services regularly bought and sold in markets.

The evaluation of a capital investment or a medical intervention in the health sector is seldom subjected to a cost-benefit analysis because of the difficulty in measuring the outcomes of the project in monetary terms. For example, the value of human life and the value of improvements in human health are difficult to quantify in a satisfactory manner. So far two approaches have been attempted by some researchers to measure these outcomes in monetary value.¹⁴ The first is the human capital approach where improvements in health status are considered as investments that will enhance productivity and increase incomes. But this approach only focuses on earnings potential; the value of benefits is considered to be biased downward because it ignores other benefits. The second approach is the

¹³ Zeinali, A., Jenkins, G.P., and Klevchuk, Andrey, “Infrastructure Choices in Education: Location, Build and Repair”, Queen’s Economics Department Working Paper, No. 1204, (April 2009).

¹⁴ Adhikari, R., Gertler, P., and Lagman, A., “Economic Analysis of Health Sector Projects – A Review of issues, Methods, and Approaches”, Economic Staff Paper, Asian Development Bank, (March 1999).

willingness to pay by consumers where one can assess the extra earnings demanded by workers to undertake risky jobs or the additional safety expenditures made to reduce the incidents of accidents. This may be considered an accepted measure of the implicit value of a life of workers. Nevertheless, the empirical results cover a wide range of values. There are also controversial issues such as the extent that younger persons are valued more than seniors.

Due to the difficulty in measuring human life or other outcomes of health interventions in monetary terms, cost-effectiveness analysis has become one of the most practical techniques in evaluating alternative health projects or programs in order to achieve specific health benefits at least cost. Given the benefits, the analyst should identify the incremental costs for each alternative option. These include capital expenditures for hospital, clinic, computer, medical equipment, etc. and operating costs for office supplies, administration expenses, wages and salaries of physicians, nurses, laboratory technicians and other staff, and so on. In the economic analysis, the cost should also include the opportunity cost of travel, waiting and forgone earnings of patients or parents of sick children.

One area that is often faced by analysts is joint production of health services. For example, some facilities and administration costs may be commonly used. The analyst should identify and estimate incremental costs associated with each alternative intervention.

15.7.2 Unadjusted Measurement of Cost-Utility Analysis

Health projects or programs typically result in multiple benefits even if a single objective is originally targeted. Using a simple cost-effectiveness analysis often omits some important side benefits. Thus, the consequential choice of handling these problems is carried out through a cost-utility analysis.

Suppose that the policymakers want to design an immunization program to maximize

improvement in health for a given budget in a particular region.¹⁵ Three alternative options are identified to be evaluated. They are DPT (a combination of diphtheria, pertussis, tetanus vaccines for children), BCG (Bacillus Calmette Guerin, used to prevent tuberculosis), and a package of both DPT and BCG combined.

The effects of these alternative options can be obtained from simulations of an epidemiological model that is devised and based on the number of vaccinations, the efficiency of the vaccines, the incidence of fatality rates, duration of morbidity, and years of life lost based on a life-table for the relevant population. The effectiveness of immunization is measured by the reduction in morbidity and mortality rates, and both can be ultimately translated into years of life. For instance, three individuals were saved with an immunization program: the first individual has avoided a loss of 5 life-years, based on his life expectancy; the second gained 8 life-years, and the third saved 3 life-years. The resulting total mortality prevented by this program, as measured in life-years, is 16 years. A similar count goes for morbidity, which presumes that a person with lower health status will eventually live a shorter life, while an individual with higher health status will enjoy more years of life. The epidemiological model makes a projection for the population in the particular region, and reports the impact of an immunization program on total life-years gained. This is the simplest type of cost-utility analysis as it accounts for mortality and morbidity both measured in number of life-years saved.

Each of the three above alternative options will result in different additional numbers of life-years gained. They are summarized in Table 15.9. The option of using DPT alone would result in a reduction of total mortality by 209 years and reduction in total morbidity by 21,401 years. The cost of this option is \$1.97 million. The second option, BCG alone, would reduce mortality by 129 years and morbidity by 2,735 years, at a budget cost of \$0.585 million. This option is not cost-effective in terms of total years of mortality and morbidity gained. However, the BCG only program is more cost-effective in terms of mortality

¹⁵ This example is adopted from Belli, P., Anderson, J.R., Barnum, H.N., Dixon, J.A., and Tan, J.P., *Economic Analysis of Investment Operations: Analytical Tools and Practical Applications*, The World Bank, Washington D.C., (2001).

prevention while the DPT only program is superior in terms of reduction of morbidity. The third option, a combination of the two programs will simply include all impacts of each of the individual vaccination methods.

Overall, DPT program is the most cost-effective among the alternatives, as it is able to save an additional year of life at the lowest cost, \$91.2 per life-year. Doing BCG vaccination alone will be the most expensive way of gaining additional life-years. A combination of both DPT and BCG results in a cost of \$104.4 per life-year, which is much lower than the option of BCG only, and only slightly more expensive than DPT vaccination. If the decision is to be taken strictly on the basis of cost-utility rule, then the strategy of DPT only should be undertaken because it is the most efficient program in terms of per-unit cost. However, if there is sufficient funding for implementing both DPT and BCG at the same time, then this option is better simply because it saves more lives than either DPT or BCG alone.

Table 15.9
Cost-Effectiveness of Alternative Immunization Programs

Options	Cost (\$000)	Life Saved			Cost of Mortality (\$/year)	Cost of Morbidity (\$/year)	Cost-Utility Ratio (\$/year)
		Mortality (years)	Morbidity (years)	Total (years)			
DPT	1,970	209	21,401	21,610	9,408	92	91.2
BCG	585	129	2,735	2,865	4,521	214	204.2
DPT and BCG	2,555	339	24,316	24,475	7,542	106	104.4

The above example takes into consideration two aspects of health status: number of additional life-years (reduction in mortality), and condition of disability (morbidity). Reduction in both mortality and morbidity was expressed in additional years of life gained. It was implicitly assumed that the resulting additional years will have the same health status. A more elaborated method can be employed for cost-utility analysis in healthcare. This is measure in various forms of health outcomes in terms of healthy years of life gained, quality-adjusted life-years, and disability-adjusted life years.

15.7.3 Quality-Adjusted Life Years

Taking into account, but the distinction between fatal mortality and nonfatal morbidity outcomes may be most objective to measuring the outcomes of health projects. QALY is the measure that combines both the quantity, expressed in additional life-years, and their quality, expressed through a health index. This has become a major tool in appraisal of many health programs. In essence, QALY expresses a combined utility of both the additional years and quality of life during these years. The basic idea is straightforward in which it takes one year of perfect health-life expectancy to be worth one, a value of zero for death, and one year of less than perfect life expectancy as less than one. For example, an intervention results in a patient living for four years rather than dying within one year. The treatment increases three years to the person's life. However, if the quality of life falls from one to 0.8 after the treatment, it will generate 2.4 QALY. QALYs can provide an indication of the benefits gained from a variety of medical interventions in terms of quantity and quality of life for the patient. Need less to say, there are problems associated with the technique. This is because the index assigned to the state of health improvement may be subjective. Combining two distinct variables -- mortality and morbidity -- into an index is mathematically convenient. However, assigning appropriate weights and then ranking the choice among these combinations has become a major challenge for decision makers in the medical sector.

DALY is another tool and considered to be an overall measure of disease burden on an economy. It combines a years of life lost measure and a years-lived with disability measure. The DALY index calculates the productive years lost from an ideal lifespan due to morbidity or premature mortality. The reduction of productive years due to morbidity is a function of the years lived with the disability and a weight assigned. The technique allows both morbidity and mortality to be combined into a single measure. Moreover, DALY is age-weighted healthy years of life gained. It has higher weights attached to productive years as compared to a QALY where health weights are kept constant for a given health status.

A vast amount of effort has gone into research on defining a health status. Usually, health status is defined in terms of a composite index, covering most of the physical and psychological conditions. Every health aspect included in the index is rated on some scale

from the worst to the best state. A single index can then be constructed from all the aspects. For instance, one of the most comprehensive classifications is based on four dimensions: physical function (mobility and physical activity), role function (ability to care for oneself), social-emotional function (emotional well-being and social activity), and health problem (including physical deformity).¹⁶

The usefulness of QALY index in cost-utility analysis depends on the reliability of the methods used to define and to measure health status. There are three common methods of deriving utilities of health status: the health rating method, the time trade-off method, and the standard gamble method.¹⁷

15.7.4 Issues of the Analysis

Cost-utility analysis has overcome the limitation of taking account of only one type of benefit under the cost-effectiveness analysis. There are some issues, however, that require attention and further research.

First, although cost-utility analysis includes several key benefits, it relies on construction of a composite utility index and their underlying relative importance in the index. Assignment of relative weights to different types of benefits is usually based on a survey and consultation with government officials, local community, experts in the field of project. Nevertheless, they are not based on market places nor consumers' willingness to pay. Different methods of utility derivation may result in different weights and generate different results.¹⁸

Second, caveats must be placed on the process of ranking of different types of benefits due to the choice of scale on which the benefits are measured or the interaction among the

¹⁶ Torrance, G.W., Boyle, M.H., and Horwood, S.P., "Application of Multi-Attribute Utility Theory to Measure Social Preferences for Health Status", *Operations Research*, 30, No. 6, (1982), pp. 1043-1063.

¹⁷ Froberg, D.G., and Kane, R.L., "Methodology for Measuring Health-State Preferences – IV: Progress and Research Agenda," *Journal of Clinical Epidemiology*, 42, No. 7, (1989), pp. 675-685.

¹⁸ Hornberger, J.C., Redelmeier, D.A., and Peterson, J., "Variability among Methods to Assess Patients' Well-Being and Consequent Effect on a Cost-Effectiveness Analysis", *Journal of Clinical Epidemiology*, 45, No. 5, (May 1992).

outcomes. For instance, a program of drug-addicts treatment is likely to result not only in their lower mortality and morbidity but also in reduction of street crime. Because different types of benefits are often measured in different units, the choice of common ranking scale should be compatible to all the benefits.

A second problem arises when different types of benefits are ranked. If one type of benefit is ranked 80 on a 100-scale and another benefit is assigned a weigh of 40, it does not necessarily mean that the first outcome is twice as preferable.

Another caveat lies in aggregation of individual preferences. A simple summation may seem as the right way of combining individual choices into social preferences, but this procedure is not appropriate if there are interactions among individuals such that would require another method of compiling their total score.¹⁹

Third, concerns are often raised regarding discounting of health status and life-years in healthcare applications. It is unquestionable that the costs should be discounted but concern is sometimes expressed whether additional years and health status should be discounted too. If costs are indeed discounted but health and/or years are not discounted, then the cost-effectiveness ratio becomes smaller and smaller in the consequent years. Timing decisions will be biased towards future dates because the ratios improve.²⁰

When additional years and health quality are discounted, the rate used for discounting is often debatable. The general consensus is necessary for discounting health improvement and additional years gained in the future because individuals normally prefer having better health now than the distant future as well as a life saved today is more valuable than a life saved tomorrow. Nevertheless, there is still a considerable controversy over the theory, methods of measurement, and the appropriate discount rate.²¹

¹⁹ Arrow, K.J., K.J., "Social Choice and Individual Values", New York: Wiley (1963).

²⁰ Keeler, E.B., and Cretin, S., "Discounting of Life-Saving and Other Nonmonetary Effects", *Management Science*, 29, No. 3, (March 1983).

²¹ Gafni, A., "Time in Health: Can We Measure Individuals? Pure Time Preference?'"', *Medical Decision Making*, 15, No. 1, (1995).

Currently, a 3 or 4 percent rate is used by various institutions to discount the stream of benefits and costs in health projects to compare alternatives. The rate is based on the rate of time preference alone in terms of present versus future consumption. There is a serious concern that such a discount rate does not fully capture the value that society forgoes in terms of pre-tax returns of displaced investment. A rate of discount that takes into consideration the opportunity cost of forgone investments will be much higher than the rate of time preference of consumption. Note that in the case of most health interventions where the costs are spread out the time of the intervention when the benefits are also being realized, the discount rate may not be too critical. The size of discounting rates, however, would be extremely important when capital expenditures such as construction of hospital and clinics or purchase of expensive machines and other advanced equipments are incurred at the beginning of the project. Hence, a reasonable approach to the discount rate is to use a weighted average of the economic rate of return on private investment and the time preference rate for consumption as outlined in Chapter 8.

15.8 Conclusion

Given the difficulties in quantifying the outcomes in monetary value for public security, education, healthcare and other social projects, cost-benefit analysis cannot be used to evaluate their alternative options. This chapter has presented alternative approaches, cost-effectiveness and cost-utility analysis, to handle these types of projects. The general procedure requires calculation of the incremental impacts of a particular project associated with the incremental cost. The resulting marginal cost-effectiveness ratios are used to rank the alternative measures or interventions.

When only one aspect of project benefits matters, cost-effectiveness analysis offers a handy tool for selection of alternative options with technical efficiency. However, the approach does not cover more than one single benefit; other benefits may also be important and should be accounted for in the project selection.

A weighted cost-effectiveness or cost-utility analysis is generally used when multiple benefits have to be included into assessment. It is measured by a composite index to include all important factors affecting the project selection. The main advantage of this approach is that it can capture a whole host of benefits in a single measure for ranking alternative options. This is especially useful when applied to education or health projects because they usually generate multiple benefits.

As regards the costs, they can be measured at both financial and economic prices. In the economic analysis, they should be measured in resource costs over the life of the project or program. Forgone earnings, for example, should be included in the economic evaluation of secondary or higher educational programs. Likewise, travel and waiting time of patients should also be accounted for in alternative interventions of health projects.

While both cost-effectiveness and cost-utility analysis offer practical methods of selection among alternative projects or programs, both have limitations because their benefits cannot be measured by a consumer's willingness to pay at market prices. As a consequence, some subjective judgments must be made in computing a composite index even though a survey and consultation with experts in the field are frequently employed to minimize the possible bias. Other questions such as the appropriate size of the discount rate are still contentious issues, especially in health projects. Research continues in order to advance the methodology for practical application in a wide range of fields.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 16:**

COST-BENEFIT ANALYSIS OF TRANSPORTATION PROJECTS

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ABSTRACT

This chapter will focus on the problems of evaluating transportation projects in the context of the less-developed countries. Emphasis will be placed on highway projects, because these account for the bulk of transport investments in the developing parts of the world. If a project passes a straight financial test, based on the present value of its cash inflows and outflows, projects would only come if this financial NPV were outweighed by the present value of the project's various externalities. Road projects, however, carry a special interest as compared to other types of transport investments, because of the fact that they only rarely can be justified on strictly commercial considerations. Rail and air fares and port and landing charges constitute direct devices, by which the costs of the relevant facilities can, over time, be recouped from the beneficiaries. To a first approximation, therefore, the worthwhileness of such projects can be judged by the strictly commercial criterion of prospective profitability. Except for toll roads, road investments never present the luxury of such a positive financial NPV. This chapter presents a framework for the appraisal of both road improvements as well as the evaluation of new roads and new modes of travel.

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CHAPTER 16

COST-BENEFIT ANALYSIS OF TRANSPORTATION PROJECTS

16.1 Introduction¹

This chapter will focus on the problems of evaluating transportation projects in the context of the less-developed countries. Emphasis will be placed on highway projects, because these account for the bulk of transport investments in the developing parts of the world, railroad projects being largely limited to the modernization of existing facilities, and air transport and port projects, even when they are basically new, being of small magnitude relative to road investment.

If a project passes a straight financial test, based on the present value of its cash inflows and outflows, projects would only come if this financial NPV were outweighed by the present value of the project's various externalities. Road projects, however, carry a special interest as compared to other types of transport investments, because of the fact that they only rarely can be justified on strictly commercial considerations. Rail and air fares and port and landing charges constitute direct devices by which the costs of the relevant facilities can, over time, be recouped from the beneficiaries. To a first approximation, therefore, the worthwhileness of such projects can be judged by the strictly commercial criterion of prospective profitability. Except for toll roads, road investments never present the luxury of such a positive financial NPV. User charges are, of course, present in the road transport field, in the form of gasoline taxes, motor vehicle licenses and taxes, and the like. But these charges are functions of the general tax structure of the country in question, and do not vary depending on whether vehicles are used on one highway or another. They are related neither to the benefits which the users of a particular project may be expected to enjoy, nor to the costs of constructing that project.

¹ This chapter is largely drawn from the paper, "Cost-Benefit Analysis of Transportation Projects" prepared by A.C. Harberger, for a conference on "Engineering and the Building of Nations" held at Estes Park, Colorado, August 27-September 1, 1967.

This means that whereas for other important types of transport projects user charges can be taken as the first-approximation measure of benefits, for road projects we must confront the problem of estimating benefits essentially from scratch. This may be difficult or easy, depending upon the circumstances of the case. By and large, the great bulk of road projects entail improvements of existing roads or, what amounts to much the same thing, linking by a shorter and/or better road population centers that were already linked by the pre-existing network. In these cases we can in general have access to two key pieces of information of great value in estimating project benefits: (a) the actual volume of traffic now flowing between the points to be served by the road improvements, and (b) the probable reduction in costs of travel per vehicle-mile that will occur as a consequence of the improvement. It will be seen below that with the aid of these two types of facts, reasonably accurate measurements of the prospective benefits of road-improvement projects can normally be made.

Such is not the case with respect to totally new roads that penetrate areas not yet served by the highway network. For these roads, the prospective volume of traffic is much more of an unknown than in the case of road improvements, and the benefit per user, which for the road improvement can be measured quite accurately in terms of cost-reduction per vehicle-mile, now presents more formidable problems of estimation.

16.2 The Case of Road Improvements

It is of the nature of the case that projects of road improvement do not bring into being possibilities of vehicular transport which did not exist before. They may generate new traffic owing to the fact that they reduce costs of travel, but the bulk of the traffic to be served by the improved road is likely already to have been travelling on the existing one. This means that the bulk of the benefits stemming from the improvement are likely to accrue to traffic that would in any case have passed over the road in its unimproved state.

The direct benefits of a road improvement all involve savings of costs. The better the road, in general, the lower will be the consumption of gasoline and oil, the less the wear-and-tear on tires,

the lower the incidence of repair and maintenance expenses, and the longer the useful life of the vehicle using it. Traffic engineers have provided us with the technical coefficients relating the quality of the road and the speed travelled to the vehicle operating costs in terms of quantities of inputs required by type of vehicle. For example, fuel consumption will vary with the type of road (earth, gravel, paved) for automobile, buses and size of truck. It will also vary by speed of vehicle, by the rate of rise or fall of the road, and by the degree of curvature of the road. In a similar fashion, for each type of vehicle, engine oil consumption, tire wear, maintenance costs and depreciation of vehicles will vary with the type of road and the speed of travel.

Additional savings beyond those connected directly with vehicle costs include the saving of time for occupants of the vehicles, the savings of maintenance expenditures on the road itself, and the possible reduction in the costs of accidents as a result of the road improvement. Of these, the first two are usually the most important. If the time of the occupants of a vehicle is valued at \$10 per hour, this amounts to \$.40 per vehicle-mile at 25 mph and .25 per vehicle-mile at 40 mph – the saving of .15 per vehicle-mile is clearly large in comparison with the likely reduction in direct vehicle costs associated with an improvement from earth to gravel. Of course, the value of this saving is tied to the value placed on the hour of occupants' time, and is therefore sensitive to the level of living in the country. In a very low-income country such as India, the time-saving aspect of road improvements is likely to contribute little to the overall estimate of their benefits, but even at relatively modest income levels it has an important effect – a saving of \$.01 per vehicle-mile arising from the above-assumed increase in speed at a value of \$.37 per vehicle-hour.²

With respect to road maintenance costs, it is clear that improvement can often generate substantial savings. A study based on Venezuelan data estimated that the maintenance costs of a gravel road were equal to those of an earth road at an average traffic level of 100 vehicles per day; beyond this travel level there was a saving of over \$.02 per vehicle kilometer involved in having gravel. Similarly, the maintenance costs of paved and gravel roads were estimated to be

² Note that the average vehicle carries more than one passenger. Suppose there are on average 1.8 passengers per automobile and of 1.2 passengers per truck. The saving of \$.01 per vehicle mile would therefore be reached at a value of time of about \$.37 per hour for occupants of passenger vehicles and of about \$.56 per hour for the occupants of trucks.

equal at an average daily traffic of 300 vehicles per day, beyond which there was a saving of over \$.02 per vehicle kilometer entailed in having a paved as against a gravel road.³

We now turn to the basic procedure for evaluating the direct benefits of a particular road improvement. First, we estimate, on the basis of current observed traffic volume, its past trend, and the likely rate of growth of the economy in the area, a projected time-path for the traffic volume of vehicles of each type, assuming that the improvement is not made. This will generate i time-series, V_{it} where V stands for traffic volume, i for type of vehicle, and t for time. We sum these for each year to obtain $V_t (= \sum V_{it})$, the volume of traffic that we expect for each year. On the basis of the expected volume, we then project the estimated average speed of traffic on the road in year t . This can be done either by using direct observations on the relationship between average speed and traffic volume on the road in question, or, if those are not available, by using functional relationships between speed and traffic volume for the particular type of road. Such relationships have been estimated for many years by the U.S. Bureau of Public Roads and other highway authorities. We thus obtain $S_{it} = f(V_t)$, where S_{it} is the average speed of the i^{th} vehicle type.

The estimates of average speed, together with the characteristics of the road (such as gradient and curvature) enable us to estimate the average cost, c_{it} , per vehicle mile at time t for vehicles of class i on the unimproved road.

We next must estimate corresponding figures for the improved road. If traffic volumes are not expected to be different regardless of whether the road is improved or not, this is an easy task. It simply entails inserting the estimated V_t into the equation setting out the relationship between average speed and traffic volume for roads of the type (such as two-land gravel) being planned. The estimated speeds s_{it}' thus obtained, along with the gradient and curvature characteristics of the proposed improved road, enable us to estimate the prospective average costs c_{it}' of travel on that road for each vehicle class.

³ Richard M. Soberman, "Economic Analysis of Highway Design in Developing Countries", Highway research Board, *Highway Research Record*, No. 115 (publication 1337), 1966.

Included in c_{it} and c'_{it} should be all costs perceived by the owners and occupants of the vehicles – including fuel, oil, maintenance, repair, depreciation, and the time costs of the occupants. The benefits accruing in year t to the owners and occupants as a consequence of the proposed improvement are therefore estimated as $\sum_i (c_{it} - c'_{it}) V_{it}$, and the present value of this class of benefits is $\sum_i (1+r)^{-t} \sum_i (c_{it} - c'_{it}) V_{it}$, where r is the rate of discount used for purposes of cost-benefit analysis and the current year is taken as the origin for the purpose of measuring time. To these benefits we must then add the prospective savings in maintenance costs, $M_t - M'_t$, where M_t refers to maintenance costs on the unimproved road and M'_t to those on the improved road. These will be functions of the prospective traffic volumes V_t , and should be estimated on the basis of them. The expression for the present value of total direct benefits (accident prevention is assumed to be a negligible component of total benefits) is therefore:

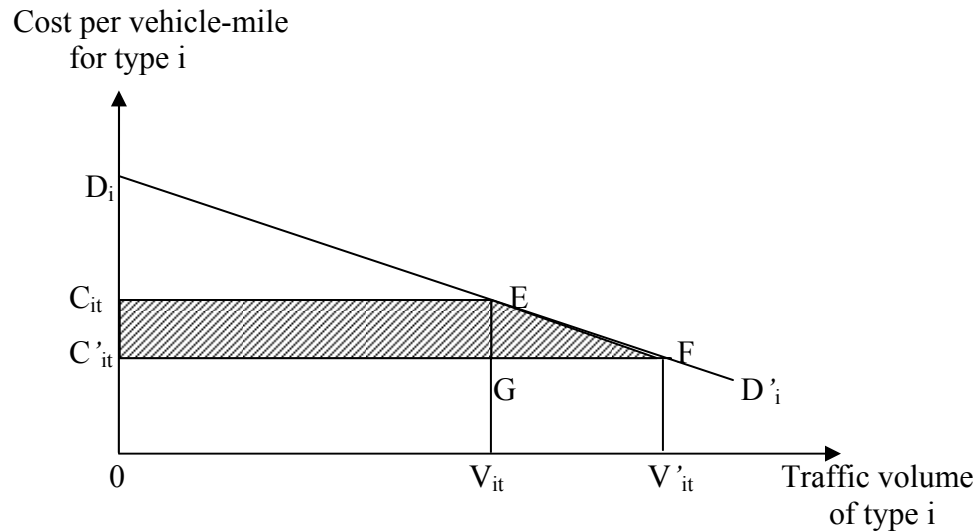
$$\sum_t (1+r)^{-t} \sum_i (c_{it} - c'_{it}) V_{it} + \sum_t (1+r)^{-t} \sum_i (M_t - M'_t) \quad (16.1)$$

When it is anticipated that the traffic volume at time t will increase as a direct consequence of the improvement, the analysis becomes slightly more complicated. First, one must estimate the expected increase in traffic ($V'_{it} - V_{it}$) of different types. Then on the basis of V'_t ($=\sum_i V'_{it}$) one should estimate S'_{it} , using the functional relationship between speed and volume for roads of the improved type. Using these speeds, one then proceeds to estimate the average costs per vehicle-mile – c'_i -- under the proposed changes in road characteristics. And using the prospective volumes of traffic V'_{it} one estimates the projected road maintenance costs M'_t . With these modifications in methodology, formula (16.1) remains valid as a measure of the present value of a large part of total direct benefits, but omits one component thereof – the gain in consumer surplus to the newly generated traffic. This additional traffic can come from more frequent use of the road after it is improved by those who already travel on the road (generated traffic), plus those who now use the improved road but previously travelled on another road (diverted traffic).

This is illustrated in the Figure 16.1. Here $D_i D'_i$ represents the demand function for the use of the road by vehicles of type i . On the vertical axis is measured the price that each successive unit

of traffic would be willing to pay, per vehicle-mile, for traveling over the road. This price should be interpreted as the maximum total cost per vehicle-mile which that unit of traffic would be willing to bear, in order to travel on the road. With the unimproved road, the cost per vehicle-mile is c_{it} , and the corresponding traffic level V_{it} includes all those traffic units willing to bear costs of c_{it} or more. Under the improvement, costs will fall to c'_{it} and traffic volume will now expand to V'_{it} . The gross benefits received by the incremental traffic are measured by $V_{it}EFV'_{it}$, but the costs they perceive are $V_{it}GFV'_{it}$. Therefore the triangle EFG measures their net benefit for the year t . They do not receive as much net benefit as the existing traffic because some of the reduction in costs per vehicle-mile is of no relevance for them. If c_{it} is 10 cents and c'_{it} is \$.07, a potential traveler willing to pay no more than 8 cents to use the road obtains no benefit from a reduction in cost from \$.10 to \$.08; at that point he may use the road, but he will be on the margin of indifference between using it and not using it. If the use of the road is now made available to him at a cost of \$.07 per vehicle-mile, the measure of his net benefit is \$.01 (= \$.08 - \$.07), while those who were already paying \$.10 to use the road in its unimproved state will perceive a benefit of \$.03 per vehicle-mile.

Figure 16.1: Direct Benefits for Road Improvement



If the demand curve for the services of the road is linear, or if not, taking a linear approximation to that curve, we may express the triangle EFG as $\frac{1}{2} \sum_i (c_{it} - c'_{it}) (V'_{it} - V_{it})$. We must therefore add to (16.1) the expression

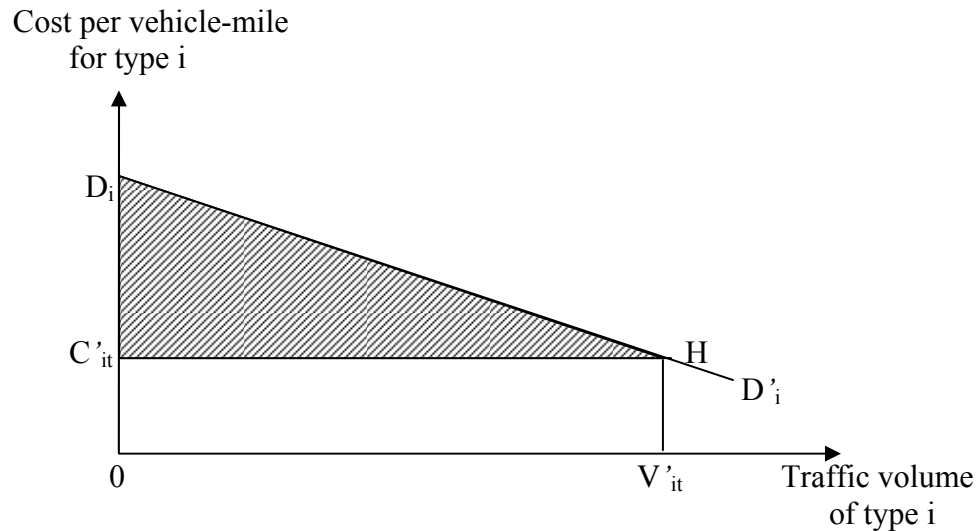
$$\frac{1}{2} \sum_t (1+r)^{-t} \sum_i (c_{it} - c'_{it}) (V'_{it} - V_{it}), \quad (16.2)$$

in order to capture that component of benefit represented by consumer surplus accruing to traffic generated directly as a consequence of the improvement.

16.3 The Case of Penetration Roads

When a road is built into an area to which access by motor vehicles was previously impossible, the analysis of Section 16.2 remains in principle unchanged, but in practice significant modifications in approach may be required. The difficulties here stem from the fact that V_i is zero, hence the component of benefits represented by $C_{it}EGC'_{it}$ in Figure 16.1 simply does not exist. All traffic is newly generated by the presence of the road, and all direct benefits to users therefore are in principle of the type represented by the triangle EFG . Figure 16.2 represents such a case.

Figure 16.2: Direct Benefits for New Road



Here the annual net benefit to users of type i is given by the triangle $D_iHC'_{it}$, which corresponds exactly to EFG in Figure 16.1. The special problems presented by the present case arise because (a) whereas for improvement of existing roads the increment in volume caused by the

improvement ($V'_t - V_t$) is likely to be relatively small in relation to V_t , this increment represents the entire volume of traffic in the case of a penetration road, and (b) whereas, in the case of road improvements, the costs per vehicle-mile c_{it} and c'_{it} of a given amount of traffic in the existing and improved roads can be rather precisely estimated, thus giving us a good estimate of the height of the triangle EFG , we do not have any correspondingly precise estimate of the height of the triangle $D_iHC'_{it}$ in the case of a penetration road. A problem is raised by (a) because the increment of traffic caused by an improvement is obviously subject to greater estimation error than the traffic based on the normal expansion of what we observe today; for a road improvement this error applies to a relatively small part of the total direct annual benefit, while for a penetration road the error applies to more than the whole (more, because from the triangle $D_iHC'_{it}$ we must deduct the annual maintenance costs of the road, M_t). A problem is raised by (b) because the existing cost of moving goods and people into an area to be newly penetrated by a road is likely to be high (if not, as, for example, in the case of easy transport by water, the analysis becomes quite similar to that of a road improvement). This cost does not provide a useful estimate of the location of point D_t . Moreover, the assumption of linearity of the demand curve for the services of the road, which is likely to yield a good approximation, when, as in Figure 16.1, the relevant points (E and F) are not too distant from each other, is much more precarious in the case of Figure 16.2, where deviations of the segment D_iH from linearity could have a substantial effect on the area of $D_iHC'_{it}$.

The above-mentioned types of difficulties encountered in the analysis of penetration roads can make it advisable in some cases to use alternative approaches to the estimation of benefits. The simplest case is that of an isolated mine, where the problem of access to the mine should be thought of in the course of deciding on the worthwhileness of exploiting it. If the traffic to be carried over the road is to be exclusively or almost exclusively connected with the operation of the mine, then the enterprise exploiting the mine should also bear the costs of the road. If under these circumstances the mine is not an attractive venture, the implication is that it is not advantageous to the society as a whole to exploit the mine. (Needless to say, this conclusion could be reversed if externalities were present in sufficient amount, but this qualification would apply to any apparently unprofitable investment whatever.)

A more complex case is that of a road which is opening up a new area to agricultural exploitation. Here the essence of the problem can best be seen by assuming that the area to be opened up consists entirely of public lands that have no value at present, owing to their remoteness. The benefits attributable to the road project would then be the total estimated yield which the government could get from the sale of the lands once the road was built, assuming that the market for land would be functioning well. If the land already had a value in its existing state, the benefit attributable to the road would be the excess of the prospective sale value of the land over its present market price.

Institutional arrangements and market imperfections, however, can make land-value comparisons fall wide of the mark as estimates of the benefits of penetration roads. To mention the most obvious case, the land (here assumed to be privately held) may have no true economic productivity in the absence of a road, but it may have a positive market price today because its owners anticipate that the government someday will build a road into the area. In this case, the prospective sale value of the land, once the road is built, and not the difference between this and today's market value of the land, is the relevant measure of the road's benefits. A second problem concerns possible improvements of the land. In all uses of land-value comparisons to assess the benefits of a road, the costs of any improvements in the land (clearing, leveling, irrigating, and so forth) which do not already exist today should be deducted from its prospective future value before attributing any benefit to the road.

Where direct use of land value comparisons is found to be unwarranted or excessively risky, one may attempt to assess the benefits of a road opening up a new area to agriculture on the basis of prospective agricultural production. Here, once again, care must be taken to deduct from the value of prospective farm output all the relevant associated costs, including those of clearing and improving the land (capital costs) as well as such current costs as labor, fertilizer, and transporting the inputs and outputs of agriculture over the road itself. And to the extent that complementary social investments such as the provision of electricity or drinking water are entailed in opening up the area to agriculture, their costs, too, must be deducted from the value of

prospective farm output, before arriving at the benefit due to the road itself. Or, what amounts to essentially the same thing, the entire set of investments entailed in opening up the area can be evaluated as a 'package', weighing the discounted value of expected flows of agricultural output against the discounted sum of all costs -- capital and current, public and private -- entailed in bringing forth that output.

It is of utmost importance to recognize that the use of changes in land values, the use of the present value of changes in agricultural output less costs and the estimation of the present value of annual triangles $D_t HC'_{it}$ in Figure 16.2 are three *alternative* ways of getting at essentially the same thing. If initially land prices contain no speculative component anticipating that a road would be built, the rise in land values induced by the road is simply the capitalized value of benefits obtained but not paid for by road users. It may not capture all of $D_t HC'_{it}$ for some users of the road other than farmers may be capturing part of it, and some road benefits perceived by farmers may not be capitalized into land values. But in any case the rise in land values is not additional to the present value of the demand triangles. Similarly, we can represent today's non-speculative value of land as the present value of expected future net output in the absence of the road, and relate it to a corresponding value in the presence of the road. This means that the change in land value will be the present value of the increase in output due to the road less the present value of the additional farmowner capital and current costs of achieving that output. Failure to recognize these three approaches as alternative ways of measuring the same thing has often led to double counting of benefits and even in some cases to triple counting!

16.4 Externalities Connected with Road Projects

It is appropriate, in the analysis of any project from the point of view of society as a whole, to take into account external or indirect benefits and costs. These can conveniently be summarized in the formula $\sum_i D_{it} (X'_{it} - X^o_{it})$, where D_{it} is the excess of benefits over costs associated with a unit change of the level of activity X_i at time t , X'_{it} is that level in the presence of the project in question, and X^o_{it} is that level in the absence of the project. Thus, for example, X_{1t} might be the number of unskilled laborers employed in a particular textile plant, and D_{1t} might be the excess

of the wage paid to them over opportunity cost of their labor in alternative employments. Similarly, X_{2t} might be the output of a tire factory, and D_{2t} might be the excise tax collected per tire, representing the excess of the social benefit (here measured by the market price people pay for tires) over the resource cost of producing them. If, owing to the existence of a road project, more or less unskilled labor were to be employed in the textile plant, or more or less tires were to be produced in the tire factory, indirect benefits or costs, as given by the formula presented above, would have to be attributed to the project.

There is nothing in the cases cited above that is unique to road investment projects. If we were considering an electricity project or an irrigation project, we would want to ask how the level of employment of unskilled workers in the textile plant and how the output of the tire factory would change, if at all, as a consequence of the project, just as we would do in the case of a road project. In principle, the authorities in charge of project evaluation ought to identify all activities X_i for which marginal social benefit differs by a meaningful amount from marginal social cost, and to provide project evaluators with estimates of the extent of the corresponding distortions, D_i . The project evaluators would then estimate the changes in the relevant activity levels caused by each particular project, to obtain $\sum_i D_{it} (X'_{it} - X^o_{it})$ for each year of the project's expected life, as a summary measure of the project's indirect benefits or costs.

16.4.1 Externalities Involving Traffic on Other Roads

Although, then, the general procedure for dealing with externalities contains nothing peculiar to road projects, there are nonetheless two types of distortions which are of special interest where road projects are concerned. These are (a) the likely excess of marginal social cost over marginal social benefit for traffic on roads, and (b) the likely excess of marginal social benefit over marginal social cost for traffic on railroads. Some readers may be surprised by the assertion that an excess of marginal cost over marginal benefit is likely in the case of road traffic, but a little reflection is sufficient to establish the point. All the studies that have been done of the relationship between average speed and volume of traffic on particular roads have shown that the higher the traffic volume, the lower the average speed. This negative relationship applies even at

relatively low traffic volumes, long before anything that one might call congestion sets in. The consequence is that an increment of traffic on a road has the effect of slowing up the pre-existing traffic, increasing its cost per vehicle-mile in terms of the time spent by the occupants and possibly in terms of other costs as well.

Let the function relating speed to volume be:

$$S = a - bV, \quad (16.3)$$

and let the value of the occupants' time be H per vehicle-hour. The time-cost perceived by the occupants of a typical vehicle will be H/S per vehicle-mile; this is also the marginal private time-cost as seen by the typical driver. The total time cost of all users of the road will be VH/S , and the marginal social time-cost will be:

$$\partial(VH/S)/\partial V = H [S - V (\partial S/\partial V)] / S^2 = H [a - bV + bV] / V^2 = aH/S^2. \quad (16.4)$$

Thus marginal social cost exceeds marginal private cost by the percentage:

$$(MSC - MPC)/MPC = [aH/S^2 - H/S]/(H/S) = (a - S)/S. \quad (16.5)$$

This expression can be easily interpreted as the 'percentage speed deficit'. If, on the type of road in question, the average speed of travel (a) at very low traffic volumes is 60 miles per hour, and if at the actual traffic volume average speed is 40 miles per hour, then marginal social time-cost exceeds marginal private time-cost by 50 percent $[=(60 - 40)/40]$.

The presence of this externality suggests the possibility of collecting a tax (a congestion toll), which would face travelers with a marginal private cost equal to the marginal social cost entailed in their trips. A gasoline tax operates in a rough way to help offset the discrepancy between marginal private and marginal social cost of travel. But it is at most a very imperfect offset, as the discrepancy between social and private costs varies greatly with the volume of traffic, while

the amount of gasoline consumed per mile is almost constant. Table 16.1 shows how the optimum tax (one designed just to offset the discrepancy between marginal social and marginal private costs) would vary for different speeds and different values of the percentage speed deficit, assuming the vehicle-hour to be valued at \$1. It is seen there that where average speeds are as low as 20 miles per hour (as is often the case on earth and gravel roads), the optimum tax is likely to be in excess of \$.01 per vehicle-mile. And even at a speed of 40 miles per hour, an optimum tax of 1 cent per mile would not be rare -- this would require a speed deficit of 40 percent, meaning a situation in which the average speed of unimpeded traffic would be 56 mph as compared with an actual average speed of 40 mph. It is unlikely, therefore, that gasoline taxes compensate for more than a part of the typical discrepancy between social and private costs -- particularly when one realizes that the heaviest volumes of traffic occur at the times when the speed deficit is greatest, the latter being a direct function of traffic volume. We proceed, then, under the assumption that, in general, marginal social costs of travel on roads exceed marginal private cost, even when the offsetting effects of gasoline taxes are taken into account.

TABLE 16.1
Excess of Marginal Social Cost over
Marginal Private Cost per Vehicle-Mile
(Based on assumed value of time of \$1 per vehicle-hour
and gasoline tax of zero)

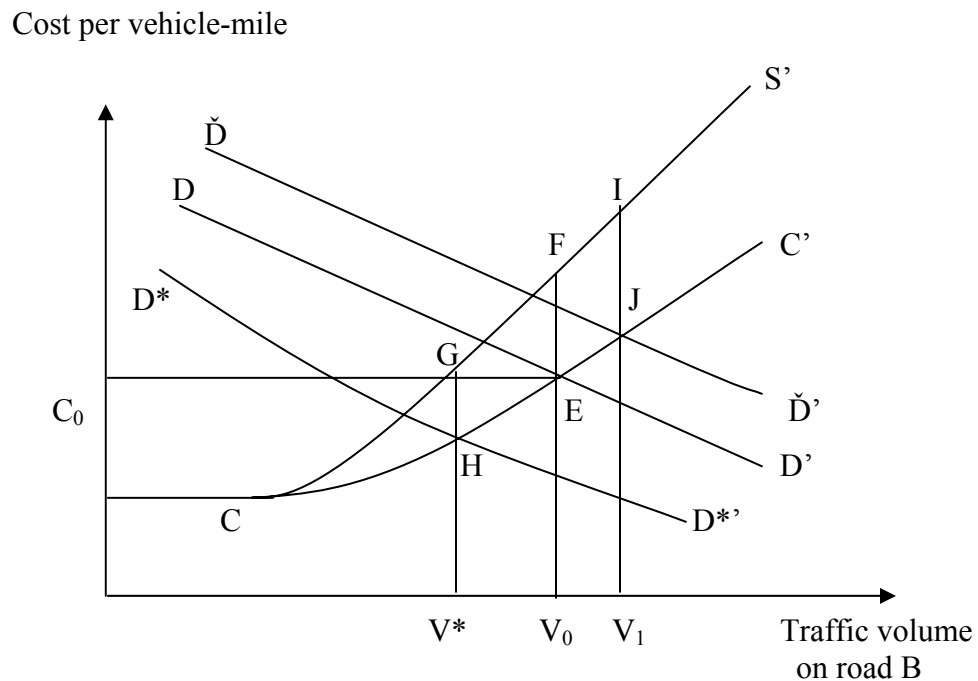
$(a-S)/S$	Miles per hour			
	20	30	40	50
.10	\$.005	\$.0033	\$.0025	\$.002
.20	.010	.0067	.0050	.004
.30	.015	.0100	.0075	
.40	.020	.0133	.0100	
.50	.025	.0167		

We now distinguish two cases in which adjustment is warranted for externalities of the type we have been discussing, the first being a case in which the road improvement in question is a substitute for existing roads, and the second in which the relationship is one of complementarity. Broadly speaking, one can identify substitutability with urban complexes, in which there normally exist many alternative routes to get from one place to another, and complementarity with rural roads where there is normally only one relevant route between two places. In the case of substitutability, a part of the newly generated traffic on the improved road will have been

diverted from other roads. An external benefit appears here, for there is now less traffic on the substitute roads, and such traffic as remains will move faster, implying a saving of time-costs for the occupants of those vehicles. In the case of complementarity, traffic volumes will increase on the roads feeding into and out of the improved segment; travel on these roads will therefore be slower, implying an increase in the cost of travel for using them.

These effects are illustrated in Figure 16.3, which depicts the situation on a road, *B*, either competitive or complementary with the one (road *A*) on which the improvement is to be made. For simplicity, the traffic on this road is assumed to be all of one type, so that the costs facing each unit of that traffic will be the same for all vehicles. Let *DD'* be the demand curve for travel on road *B*, and let *CC'* be the curve relating private costs of travel per vehicle mile to the volume of traffic on that road. *CS'*, the curve marginal to *CC'*, represents the marginal social cost of travel on road *B*. The initial equilibrium, before road *A* is improved, will be at the traffic volume V_0 , where the private cost curve intersects the demand curve.

Figure 16.3: Externalities for Substitute and Complementary Roads



If road B is competitive with road A , the improvement of A will cause the demand curve for travel on B to shift to the left, taking the position, say, $D^*D^{*'}$, and producing a new equilibrium level of traffic of V^* . The external benefit caused by the diversion of $(V_0 - V^*)$ units of traffic from road B will be measured by the area $EFGH$.

If road B is complementary with road A , the improvement of A will cause the demand curve for travel on B to shift to the right to the position, say, $\check{D}\check{D}'$ and yielding the equilibrium traffic volume V_1 . The external cost associated with the increase in traffic volume on B will in this case be measured by the area $EFIJ$.

Unless the change in traffic volume is large in relation to its initial level, the area $EFGH$ or $EFIJ$ can be closely approximated by the formula $C_0 f \Delta V (a - s_0) / s_0$. Here C_0 is the initial cost per vehicle-mile on road B , f is the fraction of C_0 represented by time-costs, ΔV is the change in traffic volume on road B induced by the improvement of A , a is the average speed of unimpeded traffic on roads of the same type as B , and s_0 is the initial average speed of traffic on road B . Here C_0 is equal to the height $V_0 E$; $C_0 f$ that part of $V_0 E$ represented by time-costs; and $(a - s_0) / s_0$ is the fraction of $C_0 f$ that represents the excess of social over private costs in the initial situation. Thus, $C_0 f (a - s_0) / s_0$ is equal to the height EF . The approximation involved in the formula therefore entails assuming that the vertical distance between CC' and CS' remains constant at EF over the range of the change in traffic volume, rather than increasing to IJ in the case of growing traffic volume or declining to GH in the case of reduced traffic volume.

When traffic on a number of different roads is likely to be affected by the improvement of road A , the technique outlined above should be applied to each of them. This leads to an expression for the external effects of the improvement of A which is equal to $\sum_j C_{0j} f_j \Delta V_j (a_j - s_{0j}) / s_{0j}$ where the symbols have the meanings defined above, and the index j varies over the number of other roads on which traffic volume is affected by the improvement of road A . Typically it will be necessary to distinguish, for a given road, between periods with different initial traffic volumes. In this event, we may define several traffic volume intervals V_{jk} on road j ; associated with each

such interval will be a level of private costs, C_{0jk} , a fraction f_{jk} of such costs that is represented by time-costs, and an average speed of traffic s_{0jk} . The measure of the external effects of the improvement of road A then becomes:

$$E = \sum_j \sum_k C_{0jk} f_{jk} \Delta V_{jk} (a_j - s_{0jk}) / s_{0jk}$$

This expression should be estimated for each year of the expected life of project A , and the value $\sum_t (1+r)^{-t} E_t$ should then be subtracted from the estimated present value of direct benefits of A . Note that E will be negative if substitute roads predominate in the set j , so that in this case net benefits will be algebraically larger after making the adjustment for these external effects.⁴

16.4.2 Externalities Involving Railroad Traffic

The problems involved in the relationships between road and rail transport can be complex, owing to the difficulty of isolating the relevant costs of rail transport. The marginal costs of carrying additional passengers or freight on trains which are in any event running are very low indeed; the marginal costs of running additional trains on runs where the track and station facilities will in any event be kept in working condition are at an intermediate level; and the marginal costs of providing rail service on a stretch of track as against the alternative of abandoning that stretch are higher still.

In what follows, we shall assume that the basic relationship between road and rail transport is one of substitutability, that is, that a project of road construction or improvement will tend to reduce the volume of rail traffic, if it has any effect at all on it. Consider now a road from B to C , which parallels a railroad that runs from A to D . Assume also that the stretch from B to C is but a

⁴ A similar adjustment of the analysis to take account of differing traffic volumes at different times is advisable in the analysis of the direct benefits of a road improvement, which was outlined in Section 16.2. The first term in expression (16.1) would then become $\sum_t (1+r)^{-t} \sum_i \sum_k (c_{itk} - c'_{itk}) V_{itk}$, and expression (16.2) would become $\frac{1}{2} \sum_t (1+r)^{-t} \sum_i \sum_k (c_{itk} - c'_{itk}) (V'_{itk} - V_{itk})$. This adjustment allows us to take account of the fact that the benefits of a road improvement are likely to be greater, per vehicle-mile, in periods of high traffic density than in periods of very low volume with essentially unimpeded flow.

small fraction of the total distance from A to D , and that all trains on the railroad ply the full distance from A to D , at least some of them stopping at B and C .

Under the above assumptions, it is likely that the improvement of the BC road will divert some traffic that otherwise would move by rail between these points. It is not likely, however, to affect the volume of rail traffic moving between A and B , between C and D , or between A and D . In this case the diversion of traffic from rail to road will probably not cause a reduction in the number and size of trains moving between A and D ; they will just have more excess capacity than before over the stretch from B to C .⁵ When traffic is thus diverted from rail to road, we measure the direct gross benefits of the diverted traffic as the area under the demand curve for travel on the road, and the direct costs as the average costs per vehicle-mile in the new situation, multiplied by the number of vehicle-miles of traffic diverted from the railroad. What have we neglected here? First, the diverted traffic ceases to benefit from the use of the railroad; we measure these forgone benefits by the passenger fares and freight rates that this diverted traffic would have paid to the railroad in the absence of the improvement. Second, the railroad no longer has to bear the marginal cost of carrying the diverted traffic. These are likely to be very low in relation to fares and freight rates in the case we are now examining. The net external effect will therefore almost certainly be negative, and will be measured by $\sum_i (F_i - R_i) \Delta X_i$, where F_i is the fare or freight rate for the i^{th} type of rail traffic, R_i is the marginal cost associated with carrying that traffic, and ΔX_i is the change in the volume, induced by the road improvement, of the i^{th} type of traffic on the railroad. In some cases of this type, the relevant marginal costs of rail transport may be so low that one can safely neglect them, in which event the measure of the net external effect produced by the road improvement becomes $\sum_i F_i \Delta X_i$, which is equal to the loss of revenue to the railroad which the road project has occasioned.

The intermediate case occurs when the diversion of traffic to the road permits the railroad to reduce the number and/or size of trains. This can occur on a stretch like BC , if that stretch

⁵ Some reduction in the size of trains may be occasioned by the road improvement if, before the improvement, the heaviest traffic volumes on the railroad were between B and C . In this case, the demand for rail movement between B and C would be the determining factor governing the size and/or number of trains, and a reduction in that demand would permit shorter and/or fewer trains. In the text, we assume that the BC stretch does not have this characteristic.

previously carried the heaviest traffic volumes on the railroad and hence determined the size and number of trains. However, it is more likely to occur where the road project connects one of the principal terminals of the railroad with some intermediate point -- for example, if the road project is between C and D . In this event, some trains which previously went from A to D could now be turned around at C , reducing thereby the amount of equipment that the railroad had to operate and maintain, and the outlays of the railroad for operating and maintenance personnel. The savings of these costs must accordingly be added to $\sum_i (F_i - R_i)\Delta X_i$ before arriving at our estimate of the net external effect associated with diversion of traffic from the railroad. In practice, however, the added saving is unlikely to be sufficiently large to convert a net diseconomy into a net external benefit.

The final case occurs when the road project permits the abandonment of a segment of track. For this to occur the road project must almost necessarily connect a terminal point with an intermediate point along the road. The savings here include not only the direct marginal costs of haulage, and the costs of equipment and maintenance which are saved by reduced rail traffic levels, but also the costs of track maintenance and repair, station operation, and so forth, over the stretch of track to be abandoned. Usually, moreover, the railroad right-of-way and its station and yard properties on the abandoned stretch will have some alternative economic use; the value of these properties in their alternative uses should therefore be counted as an indirect benefit of the road improvement project.

An additional cost is entailed in abandonment, however, which we have not yet discussed. This cost arises from the fact that, so long as the stretch of railroad is not abandoned, any diversion of traffic that takes place from rail to road is voluntary, while when abandonment occurs, some traffic for which the railroad would have been the preferred mode even in the presence of the road improvement must nonetheless cease to use the rails. The situation is depicted in Figures 16.4 and 16.5.

Figure 16.4: Direct Benefits for Road Improvement

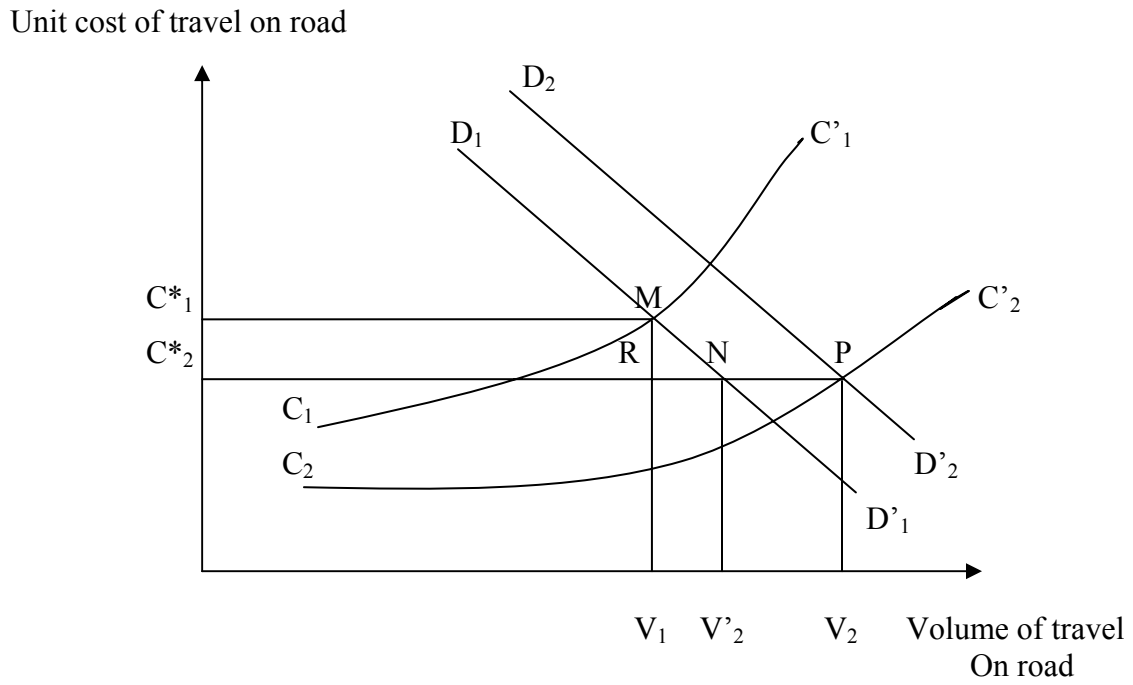


Figure 16.5: Impacts of Road Improvement on Railroad

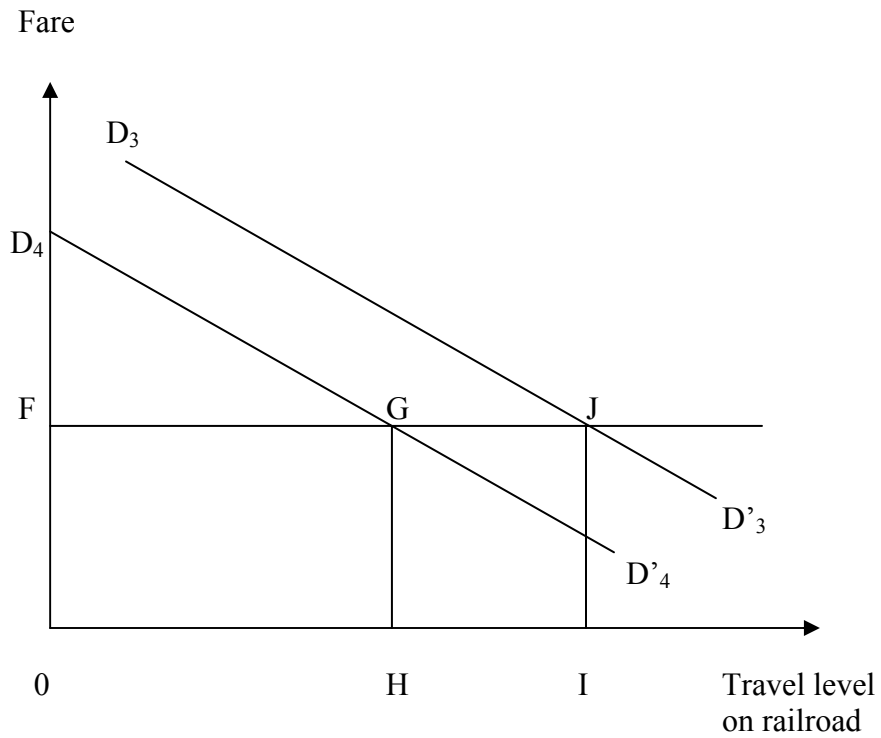


Figure 16.4 shows the situation on the road before and after improvement. $C_1C'_1$ represents the private unit costs of travel on the road before the improvement; $C_2C'_2$ after the improvement. $D_1D'_1$ is the demand curve for the services of the road on the assumption that the railroad is operating and charging the fare level OF (from Figure 16.5); $D_2D'_2$ is the demand curve for the services of the road assuming the railroad has been abandoned. C^*_1 and V_1 are the initial levels of unit costs and traffic volume on the road; C^*_2 and V_2 are the equilibrium levels after the road has been improved and the railroad abandoned. In this case the measure of direct benefits is the area $C^*_1MNC^*_2$ in Figure 16.4. The rectangle $C^*_1MRC^*_2$ represents the benefit perceived by traffic that would have used the unimproved road in any event; the triangle MNR represents the net benefit perceived by those who would not have used the road at a unit cost of C^*_1 , but who would have used it at a unit cost of C^*_2 even if the railroad were still operating. MNR includes the benefits obtained by those who would voluntarily have shifted their traffic from the railroad to the road at a road cost of C^*_2 .

The area $NPV_2V'_2$ represents the costs incurred in travel on the road by traffic that has been involuntarily shifted to the road from the railroad because of the abandonment of service on the latter. No net benefit can be attributed to this traffic because of the involuntary nature of its transfer; indeed, a net cost is involved here. This is shown in Figure 16.5, where $D_3D'_3$ represents the demand curve for the services of the railroad when the unit costs of travel on the road are C^*_1 and $D_4D'_4$ represents the same thing under the assumption that the unit costs of travel on the road are C^*_2 . The area $GHIJ$ represents the fares paid by those units of traffic which voluntarily shifted from the railroad to the road because of the road improvement. These units of traffic shift, as the costs of road travel are reduced, at the point where the cost of travel on the railroad just barely exceeds the benefit obtained from such travel. Thus from their private point of view, the benefits forgone when they cease to use the railroad are just barely compensated by the fares saved.

The situation is different for those forced from the use of the railroad because of its abandonment. Their benefits from using the railroad are measured by the area OD_4GH , while

their costs are measured by $OFGH$. From their private point of view, therefore, a loss of the triangle D_4GF is involved in the railroad's abandonment.

To summarize, then, the net benefit and cost situation of a road improvement project entailing the abandonment of service on a competing segment of railroad would be:

- (a) the present value of cost savings to the users of the road (represented by $C^*_1MNC^*_2$),
- less (b) the present value of those private net costs associated with abandonment of the railroad (represented by D_4GH),
- less (c) the present value of the excess of rail fares over the direct marginal costs of operation,
- plus (d) the present value of the savings stemming from lower equipment, maintenance, station operation costs, and so forth, for the railroad,
- plus (e) the current market value in alternative uses of the properties to be abandoned.

It is often true that the net benefits of a road improvement, taken together with the abandonment of a competing segment of a railroad line, are strongly positive. This usually occurs when the railroad's total cost of maintaining service on the segment (including (d) and (e), above) exceed the operating profit represented by (c). The heavy and persistent losses of, for example, the Argentine national railway system suggest that such cases are not at all infrequent, and that a judicious program of road improvement could prove to have net external benefits associated with rail line abandonment. Where rail abandonment is not involved, however, there is a strong presumption that the external effects associated with diversion of traffic from rail to road will be negative.

16.5 Some Implications and Generalizations

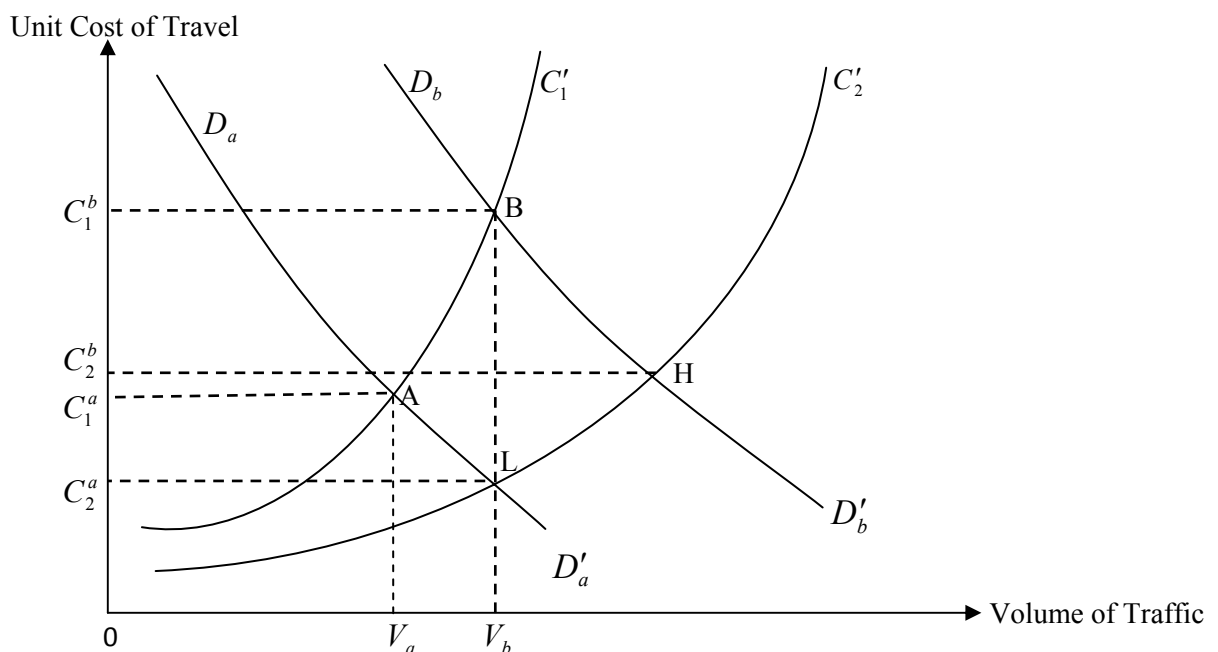
Up to now, we have set forth the basic principles and procedures to be applied in the analysis of costs and benefits of road projects. In this section we attempt to present some more general conclusions which are suggested or implied by the preceding analysis. We shall discuss, in turn,

(a) critical traffic levels, (b) stage construction, (c) the problem of timing, (d) the problem of segment construction, and (e) the road-rail problem.

16.5.1 Critical Traffic Levels

It was shown in Section 16.2 that the principal direct benefit of a road improvement was the reduction in road user costs for the traffic that would in any event have traveled on the unimproved road. The higher the traffic volume, therefore, the greater will be the presumed benefit. This is true not only because the benefits accrue to more traffic, but also because the cost-savings per vehicle, associated with a given improvement, are likely themselves to be greater at higher than at lower traffic volumes. This effect stems from the facts that costs per vehicle increase at an increasing rate with volume of traffic, and that their rate of increase at any given traffic volume is higher on poorer roads than on better roads. Figure 16.6 illustrates the point. At existing traffic volume V_a , the initial benefit $C_1^a ALC_2^a$ of the road improvement may be too small to justify the project, but if that traffic volume were greater (V_b), the initial benefit $C_1^b BHC_2^b$ would be much greater, with both the base and the height of the trapezoid having increased.

Figure 16.6: Impacts of an Increase in Traffic Volume



Since benefits are so closely related to traffic volume, it is possible, for any given road, to estimate the critical level of traffic at which it would be worthwhile to upgrade the road, say, from gravel to macadam. Moreover, given that the cost situation is basically determined by the type of road and the price and wage structure of the country in question, it should be possible for the highway authorities of a country to develop analyses showing at what critical level of traffic it will normally be worthwhile to upgrade a road from earth to gravel, from gravel to paved, from two-lane paved to four-lane paved, for example. Such analyses could usefully go into more detail, specifying critical traffic levels for a given type of improvement according to gradient, drainage requirements, nature of subsoil, and so forth.

In any event, critical traffic levels should be used as general guides to policy, not as a substitute for the detailed analysis of benefits and costs on each road. Properly employed, they serve the function of alerting the highway authorities as to which stretches of road should be considered as likely candidates for improvement, thus enabling them to employ their project evaluation personnel to better advantage.

One noteworthy aspect of critical traffic levels is that they are likely to vary considerably from country to country. Not only do costs of construction exhibit significant variation across countries, but also the benefits associated with a given improvement at given traffic levels are widely different in different countries -- in large measure owing to the extreme differences that exist in the value of time. It is highly likely, therefore, that the critical level of traffic which would justify paving a road would be much higher in India, where the time-saving element of benefits is low, than in the United States, where time-saving is likely to be the biggest component of total benefits. One must accordingly be extremely wary of 'exporting' to other countries critical traffic levels derived on the basis of the situation prevailing in a particular country.

16.5.2 Stage Construction

In light of the foregoing analysis, a strategy of stage construction of roads has a high degree of appeal. Such a strategy would entail upgrading a road from earth to gravel when the traffic level was sufficient to warrant that move, paving the road when traffic had so increased as to justify that move, and adding additional lines when that investment in turn was called for in the light of the traffic level.

Operating against the stage construction strategy is the argument that it is likely to be more costly to go through a series of upgrading investments than to build, once-and-for-all, a higher quality road than may be merited by present levels of traffic. The problem of timing will be discussed directly in the next section; we therefore here concentrate on the question of the differential cost of stage versus unitary construction.

A World Bank study reappraising a road project in Iran gives estimated costs of two-stage construction of a road -- first gravel then paved. The costs of a 5-meter-wide gravel road are estimated at 2.77 million rials per kilometer; the incremental costs of paving and widening to 6 meters are 2.0 million rials per kilometer. The total costs of single-stage construction of a 6-meter-wide paved road are 4.5 million rials per kilometer. The excess costs of stage construction are therefore estimated to be in the order of 5 percent. Similar estimates for stage construction of a 6-meter-wide gravel road, later widened to 7 meters and paved, are 3.46 million rials per kilometer for the first stage and 2.60 million rials for the second stage, as compared with 5.77 million rials per kilometer for single-stage construction of a 7-meterwide paved road.⁶

Obviously the excess costs of stage construction should be analyzed in each particular case, and compared with the extra benefits that a higher-quality road will provide. Nonetheless, the Iranian data suggest that stage construction is highly likely to be worthwhile. In the first example, the excess cost of stage construction was .27 million rials per kilometer. At a discount rate of 10

⁶ Herman G. van der Tak and Jan de Weille, *An Economic Reappraisal of a Road Project*, IBRD Report No. EC-147, p. 48.

percent (certainly not excessive for a less developed country), the interest savings on postponement would be sufficient to offset this excess cost even if the postponement of the second stage were to be as brief as 1.1 years. For the second set of data the excess cost of .29 million rials per kilometer could once again be offset by the interest saving entailed in the postponement of the second stage for as little as 1.1 years.

Nor are the incremental benefits of single-stage construction likely to justify it unless traffic levels are well above those required to warrant first-stage construction. Let V_1 be the critical traffic level which would justify construction of a gravel road, and V_2 be that which would justify upgrading to a paved road. Suppose that traffic has just now reached the level V_1 , and is expected to reach V_2 in t^* years. Let K_1 be the capital cost of constructing the gravel road and K_2 that of the paved road, and let K^*_2 be the cost of upgrading from gravel to pavement. The present value of cost saving involved in stage construction will then be $(K_2 - K_1) - K^*_2 (1 + r)^{-t^*}$. The factor $(1 + r)^{-t^*}$ is equal to approximately .6 for $r = .10$ and $t^* = 5$ years, and to approximately .36 for $t^* = 10$ years. If, as suggested by the Iranian data, K_1 is equal to $.6K_2$, and K^*_2 is equal to $.45K_2$, the present value of cost saving will be equal to $.13K_2$ when $t^* = 5$ years, and $.24K_2$ when $t^* = 10$ years. The cost of the gravel road itself being $.6K_2$, this means that the extra benefits of having a paved road instead of a gravel road during the first t^* years would have to cover 22 percent of the total costs of the gravel road in order to warrant single-stage construction if traffic would grow to justify the second stage in five years, and would have to cover approximately 40 percent of the total cost of the gravel road if t^* were equal to ten years. It should be emphasized that these extra benefits would be just those accruing during the period between construction of the gravel road and its prospective upgrading to a paved road, as subsequent to t^* the benefits of either single-stage or two-stage construction would be the same.

We conclude, therefore, that although each case should in principle be examined on its merits, there is a strong presumption that stage construction will prove to be the optimal strategy in most cases. Moreover, stage construction has the added advantage of permitting investment decisions to be based on the existing observed volumes of traffic, rather than on predictions of future traffic growth which could be subject to substantial error. In the example just presented, the fact

that traffic on an existing earth road has reached the level V_1 would be sufficient to justify the investment in a gravel road, so long as traffic was not expected to be reduced in the future. The highway authority, under stage construction, could wait to see when traffic would grow to V_2 so as to justify paving the road. If the highway authority attempts to justify now the construction of a paved road, on the other hand, it must be on the basis of a prediction of how far in the future the traffic level V_2 will be reached. If the highway authority errs in this prediction on the side of underestimating the actual growth of traffic, it may in some cases decide on multi-stage construction when single-stage construction would in fact have been economically justified. The cost of this type of error is likely to be small, however, because of the small excess of multistage over single-stage construction costs. If, on the other hand, the highway authority errs in the direction of overstating the actual growth of traffic, the error can be very costly indeed -- as traffic may not reach the point where the next stage of improvement would be warranted for 15 or 20 years, if indeed ever. The asymmetry of the costliness of errors of prediction of the two types should therefore bias the authority's choice in the direction of multistage construction.

16.5.3 The Timing Problem

In this section we discuss the problem of the timing of road investments, a problem which is made easy by the typical nature of the benefit streams generated by roads. With relatively minor qualifications, one can say that the traffic volume carried on a road, and hence the benefits of that road, will depend at any time on the quality of the road and not, to any significant degree, on when the road was raised to that level of quality. Moreover, in the great bulk of cases, the normal pattern is for the traffic on a road to grow through time.

These two characteristics -- benefits dependent on calendar time but not on the age of the project, and a rising benefit stream through time -- make the timing problem amenable to an exceedingly simple solution. Assume that we have a gravel road and are contemplating paving it. Let B_t represent the undiscounted flow of benefits (road user savings plus maintenance savings plus net external benefits that will flow from having a paved rather than a gravel road in year t). Let K be the cost of paving the road.

If, under these assumptions we face the problem of whether to pave the road in year 0 or year 1, we must recognize that regardless of which of these decisions we take, the benefits of having a paved road from year 2 onward will be obtained. The benefits lost by postponing paving for a year will be those of that year -- say, B_1 . The gains to be obtained by postponing will be the use of the amount of K of investible funds for one year; this we measure by rK , where r as before represents the rate of discount to be used in cost-benefit analysis, reflecting the productivity that investible resources could have in alternative marginal uses.

The answer to the problem is therefore simple: when $rK > B_1$, postpone; when $rK < B_1$ pave. This leads to the rule that construction should be done at the time when benefits in the first year following construction will first exceed the discount rate times the capital cost.

A slight complication is introduced when construction costs themselves are expected to change through time. If construction costs are rising, we gain by constructing at year 0 not only the benefit flow in year 1, but also the saving in construction costs ($K_1 - K_0$) entailed in building now rather than later. The rule is therefore modified to read: when $rK_t > B_{t+1} + (K_{t+1} - K_t)$, postpone; when $rK_t < B_{t+1} + (K_{t+1} - K_t)$, invest in the project. This same rule applies when construction costs are expected to decline; here one saves costs by postponing making postponement more likely.

The assumption that B_t will increase through time guarantees that $B_1 > rK$, the discounted value of all future benefits $\sum_t B_t (1+r)^{-t}$ will be greater than K (here assumed constant through time). This is the only sense in which the characteristic of growing benefits is relevant. If the future stream of benefits is expected to rise for a period and subsequently decline (as competing roads are built, for example), the basic criterion of $B_1 > rK$ remains the valid one as far as timing is concerned. Once this question has been settled, one must then make the further check to assure oneself that $\sum_t B_t (1+r)^{-t}$ is greater than K_0 . If so, year zero is the optimal time to construct the project.

Similarly, when construction costs are expected to change the criterion of $B_{t+1} + (K_{t+1} - K_t)$ exceeding rK_t remains a necessary condition for construction at time t . But if expected benefits do not continue to rise indefinitely in the future the additional condition that the present value of expected future benefits exceeds the capital cost of the project must also be fulfilled to warrant construction. If K is an increasing function of time, the above conditions are sufficient to justify construction; if K is a declining function of time a further test is necessary: $\sum_{t=0}^{t^*} B_t (1+r)^{-t}$ must exceed $K_0 - K_{t^*}(1+r)^{-t^*}$ for all $t^* > 0$.⁷

In this section we have reached the conclusion that in most cases decisions regarding the timing of road improvements will be governed by the value of benefits in the first year of operation on the improved road. Since these benefits are closely linked to the existing volume of traffic on the unimproved road, the relevance of using existing and immediately prospective traffic levels when taking investment decisions is established. Benefits in the farther future can be obtained in any event by building later; there is therefore no economic need to ‘build ahead of demand’ where road improvements are concerned.

16.5.4 The Problem of Segment Construction

⁷ All criteria derived in this section can be deduced from the basic proposition that the proper time to construct a project is that construction time for which the net present value of the project is highest, when net present value is discounted to the same point in time for all construction times being compared. The net present value of the project constructed at time zero is

$$\sum_{t=1}^{\infty} B_t (1+r)^{-t} - K_0 \quad (\text{a});$$

the net present value, as of time zero, of the project constructed at time t^* is

$$\sum_{t=t^*+1}^{\infty} B_t (1+r)^{-t} - K_{t^*}(1+r)^{-t^*} \quad (\text{b}).$$

The last condition in the text simply states that in order for construction at time zero to be optimal, (a) must exceed (b) for all t^* . A good general discussion of the timing problem, in which these issues are treated, can be found in Stephen A. Marglin, *Approaches to Dynamic Investment Planning*, Amsterdam: North-Holland Publishing Co., (1963), Chapter 2.

The preceding analysis also suggests that road improvement ought to be carried to different levels on the different segments of a given road, depending on the volume of traffic they carry. There is no reason why the road from D to G should not contain a paved segment from D to E, a gravel segment from E to F, and an earth segment from F to G, if those are the qualities of road which traffic levels on the respective segments justify. One can be sure that large amounts of investible resources have been wasted (in the sense of yielding less-than-economic returns) as a result of the penchant of highway authorities to bring all segments of a road to a given quality level. Unlike the case of stage construction, where some small cost savings may be involved in single-stage construction, construction of a road in segments is likely to be no more costly than its construction as a single project, hence unitary construction of the whole is not justifiable by cost considerations. We must therefore look to the benefit side to justify bringing the whole length of a given road to the same level of quality. Certainly cases will exist in which this decision will be warranted; they will have the attribute that each of the distinct segments of the road is carrying approximately the same amount of traffic. But most roads of significant length do not possess this attribute; hence we must conclude that optimal road investment strategies are probably not being followed in most cases where roads spanning long distances are built to a single standard of quality over their entire length.

A minor qualification to the above judgment must be introduced, however, stemming from the external effects of road improvements. The paving of a stretch of road DE will cause traffic to increase on the unpaved stretch EF as this is the path of access to or egress from DE for some of its additional traffic. The fact that DE is paved, therefore, will increase the benefits to be obtained from paving EF.

Let B_T be the total present value of benefits (direct and indirect) that would accrue from paving the entire road DF; let B_1 be the total present value of benefits of paving the stretch DE only, and B_2 the total benefit of paving the stretch EF only. Because of the complementarity between DE and EF alluded to above, we have the result that $B_1 + B_2 < B_T$. Let B_3 be the present value of benefits of paving the stretch EF, given that DE is already paved. $B_1 + B_3$ must equal B_T , since the two projects together amount to paving the entire road DF.

If K_1 represents the cost of paving DE, K_2 the cost of paving EF, and $K (=K_1 + K_2)$ the cost of paving the entire road DF, the possibility thus emerges that it would not pay to pave EF alone ($K_2 > B_2$), but that if the stretch DE was to be paved, it would also pay to pave the stretch EF ($K_2 < B_3$). It is even possible that it would not be worthwhile to pave either DE or EF alone ($K_1 > B_1$ and $K_2 > B_2$), but that paving both together would be justified ($K = K_1 + K_2 < B = B_1 + B_3$).

All of these possibilities are due to the complementarity relationship between adjacent stretches of the same road. How relevant they are likely to be depends on the difference between the traffic levels on the two stretches DE and EF. If the critical traffic level for paving either stretch alone is 1,000 vehicles per day, and if traffic has reached that level on DE but only stands at 500 vehicles per day on EF, there is no relevant justification for paving EF, once DE is paved. Paving DE is warranted, by assumption, even counting the diseconomy involved in increasing the traffic level on EF. But the increase in traffic on EF induced by paving DE will only be a part of the increase in traffic on DE; it may amount, plausibly, to 50 or 100 vehicles per day, but it would be absurd to assume that paving DE would bring traffic on EF from 500 to nearly 1,000 vehicles per day. (If 1,000 vehicles per day are required to justify paving EF alone, somewhat less than 1,000 would be required to justify paving EF when DE is also paved, because the external diseconomies associated with paving EF will be slightly less in the latter case than in the former.) Thus we conclude that if traffic on EF is quite close to the level which would justify paving that stretch alone, paving it may indeed become worthwhile when DE is also to be paved. But if traffic on EF is significantly below the critical level, it is highly unlikely that paving it will be worthwhile regardless of whether the stretch DE is paved or not. Since in the real world there are great disparities among traffic levels on given roads, we must maintain, in spite of the above qualification, our general conclusion that normally it will be optimal to upgrade different stretches of a given road at widely separated times, and that at any given time the typical road should contain stretches of distinctly disparate qualities.

16.5.5 The Road-Rail Problem

It was shown in Section 16.4 that whenever a road project would reduce rail traffic without causing abandonment of some portion of the rail line, the diversion of traffic away from the railroad would represent in all probability a negative external effect of the road project. The amount of the external diseconomy would be the fares and freight rates that the railroad ceased to collect minus any savings of costs which the railroad would have as a consequence of its reduced traffic volume. In such cases of nonabandonment, then, the only issue is to be sure to take the external diseconomy into account when evaluating the road project. If its benefits, thus adjusted, exceed its costs, the road project is justified in spite of its negative effect on rail traffic.

When abandonment of a segment of track is likely as a consequence of a road project, the cost savings to the railroad are certain to be greater than in the case of nonabandonment, and it is even possible that these savings will be sufficiently great to convert what would otherwise be an external diseconomy into an external economy of the road project. For this to happen, the present value of the cost savings to the railroad, including the value of its abandoned properties in alternative uses, must exceed the present value of the fares and freight charges that would have been paid by traffic on the abandoned line in the absence of the road project. In short, the abandoned stretch of track must have been unprofitable even in the absence of the road project, in order for abandonment to cause a net external benefit for the road investment. This case is relevant, because, for political and other reasons, many segments of track on which trains are run are kept in operation in spite of yielding large net losses. A road project may therefore, by providing alternative communication facilities of adequate quality, so reduce the political opposition to rail abandonment as to make abandonment possible.

Under the circumstances, then, of (a) abandonment of track and (b) unprofitability of the abandoned stretch in the absence of the road project, there may be a positive external effect of the road project on the operations of a competing rail line. Whether the effect will be positive or not depends on whether the loss of consumer surplus on that traffic that is involuntarily driven from using the railroad by the abandonment decision exceeds the net benefit enjoyed by the railroad on account of abandonment.

We have not discussed the case of complementarity between a road project and an existing railroad because of its relative unimportance in the modern world. In most countries, the rail facilities were built many decades ago, and the road networks early gave adequate access to the rail terminals. Thus while in principle the improvement of road access to the railroad could stimulate the use of the latter, generating a probable external benefit for the road project in question, in practice the number of such cases and the magnitude of the effects is likely to be very small. We therefore do not enter into a detailed analysis of such cases here; their proper treatment can be inferred from that described in the text for road projects that compete with railways, recognizing that increments in rail traffic where fares and freight rates exceed the relevant marginal costs of haulage will generate net external benefits to a complementary road project.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 17:**

APPRAISAL OF UPGRADING A GRAVEL ROAD

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ABSTRACT

The purpose of this chapter is to illustrate how a proposed investment in upgrading a gravel road to a tarred surface should be evaluated. The project is located in the Limpopo Province of South Africa. It involves upgrading of two existing, mainly gravel, roads into a tar surface road connecting Sekhukhune and Capricorn districts. The whole route has several sections starting from Flag Boshielo to Mafefe, Sekororo, Ga Seleka and finally to Mmatladi. It has been estimated that more than 98% of the sections of gravel road are considered in either poor or fair condition. The main users of the existing gravel road are mini-buses and private vehicles transporting people from local areas to Lebwakhomo and other towns. The predominant economic activity in the region is small-scale agriculture, carried out on a number of irrigation schemes. An lesson from this case is the importance of evaluating segments of a road separately if the traffic on the segments or the cost of upgrading are significantly different across segments.

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CHAPTER 17

APPRAISAL OF UPGRADING A GRAVEL ROAD

17.1 Introduction

The purpose of this chapter is to illustrate how a proposed investment in upgrading a gravel road to a tarred surface should be evaluated. The project is located in the Limpopo Province of South Africa. It involves upgrading of two existing, mainly gravel, roads into a tar surface road connecting Sekhukhune and Capricorn districts. The whole route has several sections starting from Flag Boshielo to Mafefe, Sekororo, Ga Seleka and finally to Mmatladi. According to the Roads Agency Limpopo (RAL), the proposed road consists of sections D4100, D4250, D4190, D4050 and D1583, with the exception on D4100 where a section of 25 km was already tarred. It has been estimated that more than 98% of the sections of gravel road are considered in either poor or fair condition.¹

The main users of the existing gravel road are mini-buses and private vehicles transporting people from local areas to Lebwakhomo and other towns. The predominant economic activity in the region is small-scale agriculture, carried out on a number of irrigation schemes. At present, no specific tourist sites are operational in the area, but it is expected that the Lekgalameetse Nature Reserve may become a tourist attraction in the near future.

The project is expected to serve some 35,000 people living in the immediate vicinity of the route, and provide a convenient access to the existing and future developments in agriculture, tourism and mining sectors.

The section of the proposed road consisting of segments D4100, D4250, and D4190 is about 81km long and it is part of the Spatial Development Rational, Golden Horse-shoe and the Dilokong sub-corridor. It is expected to support the Provincial Economic Development

¹ARCUS GIBB Ltd., "Limpopo Integrated Infrastructure Development Plan: Phase II – Benefit Cost Analysis of Selected Projects", Final Report, Appendix I: Flag Boshielo to Mafefe to Sekororo and Ga Seleka to Mmatladi, (March 2004).

Strategy. At the present time, this road serves a number of communities including 20 villages that are located directly on its way including the town of Lebwakhomo, and the communities around the Flag Boshielo Dam. Upgrading this link will ensure a convenient access for the regional population to the Lebwakhomo and Groothoek Hospitals, Jane Furse and Lebwakhomo Police Stations, and possible future sites of agriculture and tourist projects.

The other component of the proposed road improvement, consisting of segments D4050 and D1583, is about 75km long. This section already serves more than 28 villages located directly on the route, the town of Lebwakhomo, and the Lekgalameetse Nature Reserve. The improved road will facilitate an easier access to the hospitals in Lebwakhomo, Groothoek and Sekororo, as well as to police stations in Jane Furse and Lebwakhomo. Once improved, this road will provide a direct link to Tzaneen and Phalaborwa, making it convenient for vehicles to travel across the Province.

17.2 Project Costs

The project was proposed to take three years to construct, starting in 2005 and ending in 2007. For sections D4100, D4250 and D4190 that pass through a relatively flat terrain and comprising about 81 km, an average construction cost of R 1.301 million per km was estimated. For sections D4050 and D1583 that are located in mountainous area and stretching for about 75 km, the estimated costs of upgrading are higher, averaging R 1.459 million per km.

It is typical to include some provision for linking roads, which will connect the upgraded road with other roads and projects en-route. About 15 km of linking roads were estimated as a part of this road improvement project. An average construction cost of these linking roads is expected to be R 0.700 million per km. Ten small river-crossings are also included in the project; their estimated cost is R 0.040 million per km.²

In addition to the physical construction costs, professional fees are levied at 12% of the total construction expenditures. A provision for contingencies also accounts for additional 10% of the

² Ibid, p. 3-2.

total construction costs. In South Africa, the VAT at 14% rate is imposed on the total construction costs, exclusive of professional fees and contingencies.

In terms of timing, Sections D4100, D4250 and D4190, located in Sekhukhune district, have a higher traffic volume and will be upgraded in the first phase, starting at beginning of year 2005. The second phase of construction will upgrade Sections D4250 and D4190, located in Capricorn district in 2006. The last phase will upgrade one-third of 75 km of D4050 and D1583 located in mountainous area in 2006 and the remaining 50 km in 2007.³ It is assumed that the costs of linking roads, river crossings, professional fees, contingencies and VAT will be evenly spread over three years.

The total tax-inclusive investment cost of the project over three years is expected to be R 307 million in 2005 prices. The detailed cost breakdown of total investment is presented by road section and time schedule in Table 17.1. Road sections D4100 and D4250 will be upgraded first in 2005 and 2006 and sections D4190, D4050/D1583 will follow in 2006 and 2007.

³ In 2005, 34 km of D4100 and 27 km of D4250 will be built while 7 km of D4250, 20 km of D4190, and 25 km of D4050/D1583 will be built in 2006. Finally, 50 km of D4050/D1583 will be constructed in 2007.

**Table 17.1: Breakdown of Project Investment Costs
(millions of Rand in 2005 Prices)**

	2005	2006	2007	Total
Road:				
D4100	44.2	0	0	44.2
D4250	26.0	9.1	0	35.1
D4190	0	26.0	0	26.0
D4050/D1583	0	36.5	72.9	109.4
Sub-Total	70.2	71.6	72.9	214.7
Linking Roads	3.5	3.5	3.5	10.5
River Crossings	0.1	0.1	0.1	0.3
Professional Fees	8.9	9.0	9.2	27.1
Contingencies	7.4	7.5	7.7	22.6
VAT	10.3	10.5	10.7	31.5
Total	100.5	102.3	104.1	307.0

17.3 Analytical Framework

The roads of this project are owned and operated by the RAL. There is no toll imposed on road users now, nor will it be tolled after the roads are upgraded from gravel to tarred surface. As such, no financial revenues are expected from road users. Therefore, no financial evaluation will be carried out in this project. The financial outlays by the RAL will simply follow the time path of project expenditures. The objective of this chapter is to examine whether this investment promises to increase the economic welfare to residents of South African society as a whole.

To evaluate the economic impact of upgrading a gravel road, one has to measure how its effects that differ from what one would likely have observed in the absence of the project. This incremental impact analysis entails developing two alternative scenarios: “with” and “without” the proposed road improvement. The “without” scenario, which assumes the absence of the project, does not contemplate any major rehabilitation or capital outlays that will be spent on the existing gravel roads. It does, however, assume that regular normal maintenance and rehabilitation operations will continue on these roads, so that the incremental impact of the proposed project will not be overstated when compared to the “without” project scenario.

The capital expenditures of a tarred surface are typically justified by its lower annual maintenance costs as compared to a gravel surface. However, several other types of benefit must be accounted for when conducting the evaluation from the economic point of view. They should include reduction in vehicle operation costs for road users due to the improved road surface, time savings for road users due to the increased average speed of vehicles, and a possible reduction in the costs of accidents and other fiscal externalities.

Once the road is upgraded, road users will commence to travel on the tarred road. Since the total construction phase of this project will take three years and each section of the road will take approximately six months to upgrade, some improved sections may serve longer than others if the project is terminated at the same time. For the purpose of this evaluation, the project is assumed to last at least 20 years until 2027 and no salvage value remaining.

In measuring the economic benefits of transportation projects, one must distinguish between those who would use the existing road even in the absence of the improvement, and those whose travel would be newly induced as a consequence of the improvement. The benefits to the first group are measured in reduction of vehicle operating costs and time costs between traveling on the gravel and the tarred road. The benefits to the second group are measured by one half of such savings in vehicle operating costs and time costs (see Chapter 16).

To ensure a consistent transformation from all the financial costs into the economic costs used in the economic evaluation, a number of adjustments are made to convert these financial values into their corresponding economic values. To do this, Commodity Specific Conversion factors for several key project input variables are estimated, based on the methodology outlined in Chapters 10 and 11.

After all the annual benefits and costs are estimated for the “with” and “without” project scenarios, the incremental net benefits are discounted over the project life by the economic opportunity cost of capital for South Africa to see if the net present value is greater than zero.

In what follows, we will first examine individually the traffic forecasts “with” and “without” the project, plus the savings in maintenance costs, the vehicle operating costs, and time costs for each type of vehicle, and then assess the project in terms of its economic feasibility, its impact on the stakeholders affected by the project and finally, the risk inherent with this project.

17.4 Maintenance Costs

The upgraded road is expected to require substantially less maintenance care in terms of costs and repair frequency as compared to the existing gravel surface. In the case of the “without” project scenario, maintenance activities will include all regular and periodic maintenance expenditures and the rehabilitation costs of the existing road, in order for it to be held within the maintenance standards of the Road Agency. Table 17.2 presents the engineering estimates of maintenance costs of tarred (“with” project) and gravel (“without” project) roads per kilometer by type and frequency of maintenance activity for 2004. These estimates are then adjusted to year 2005, based on the annual inflation rate of 6.5%.

**Table 17.2: Road Maintenance Costs for Tarred and Gravel Road
(millions of Rand per km)**

Road Surface	Type of Activity	Frequency	Amount	
			2004	2005
Tarred (With Project)	Routine	Annual	0.030	0.032
	Intermediate	Every 3 Years	0.150	0.160
	Periodic	Every 10 Years	0.500	0.533
Gravel (Without Project)	Blading	Annual	0.035	0.037
	Wearing Course	Every 2 Years	0.200	0.213
	Heavy Gravel	Every 5 Years	0.350	0.373

Sources: ARCUS GIBB Ltd., “Limpopo Integrated Infrastructure Development Plan: Phase II – Benefit Cost Analysis of Selected Projects”, Final Report, Appendix I: Flag Boshielo to Mafefe to Sekororo and Ga Seleka to Mmatladi, (March 2004).

As previously mentioned, the construction of the project starts in 2005 in certain sections of the road and ends in 2027 for the purpose of this evaluation.

Given the estimates of the above maintenance costs per kilometer and the length of upgrading of various road sections, the annual financial maintenance costs are estimated and presented in Table 17.3 for “with” and “without” project scenarios over the life of the project. One can then

estimate annual savings in financial maintenance expenditures after roads are upgraded from gravel to tarred surface.

**Table 17.3: Estimates of Annual Financial Maintenance Costs
(millions of Rand in 2005 Prices)**

	Tarred Road (With Project)				Gravel Road (Without Project)			
	Routine	Intermediate	Periodic	Total	Routine	Intermediate	Periodic	Total
2005	3.80	0.00	0.00	3.80	5.81	0.00	0.00	5.81
2006	3.59	0.00	0.00	3.59	5.81	33.23	0.00	39.04
2007	3.39	0.00	0.00	3.39	5.81	0.00	0.00	5.81
2008	4.98	8.63	0.00	13.61	5.81	33.23	0.00	39.04
2009	4.98	8.31	0.00	13.29	5.81	0.00	58.15	63.96
2010	4.98	7.99	0.00	12.97	5.81	33.23	0.00	39.04
2011	4.98	8.63	0.00	13.61	5.81	0.00	0.00	5.81
2012	4.98	8.31	0.00	13.29	5.81	33.23	0.00	39.04
2013	4.98	7.99	0.00	12.97	5.81	0.00	0.00	5.81
2014	4.98	8.63	0.00	13.61	5.81	33.23	58.15	97.19
3015	4.98	8.31	28.76	42.05	5.81	0.00	0.00	5.81
2016	4.98	7.99	27.69	40.66	5.81	33.23	0.00	39.04
2017	4.98	8.63	26.63	40.24	5.81	0.00	0.00	5.81
2018	4.98	8.31	0.00	13.29	5.81	33.23	0.00	39.04
2019	4.98	7.99	0.00	12.97	5.81	0.00	58.15	63.96
2020	4.98	8.63	0.00	13.61	5.81	33.23	0.00	39.04
2021	4.98	8.31	0.00	13.29	5.81	0.00	0.00	5.81
2022	4.98	7.99	0.00	12.97	5.81	33.23	0.00	39.04
2023	4.98	8.63	0.00	13.61	5.81	0.00	0.00	5.81
2024	4.98	8.31	0.00	13.29	5.81	33.23	58.15	97.19
2025	4.98	7.99	0.00	12.97	5.81	0.00	0.00	5.81
2026	4.98	8.63	0.00	13.61	5.81	33.23	0.00	39.04
2027	4.98	0.00	0.00	4.98	5.81	0.00	0.00	5.81

17.5 Demand for Traffic on the Improved Road

The projected demand for traffic is the most important element in the economic analysis of a road project. The traffic forecast model used in the present analysis is based on a study completed for the Road Agency, and most of the parameters and assumptions of its model are kept unchanged. The model is built around six groups of road users, differentiated by vehicle type and purpose of journey: heavy goods vehicles (HGV), light goods vehicles (LGV), agriculture transport, tourists, passenger cars, and mini buses. For practical purposes, we combined LGV with agriculture transport. Thus, our traffic projections are carried out for five types of traffic.

The projected demand for traffic must be forecasted over the life of the project for each of the five vehicle categories under both the “with” and “without” project scenarios.

17.5.1 Traffic Level Without the Project

Given the generally poor road conditions indicated earlier, there is low traffic volume on the existing gravel road. The main users of the road are mini-buses and private vehicles transporting people from local areas to Lebwakhomo and other towns. The predominant economic activity in the region is small-scale agriculture, carried out on a number of irrigation schemes. No specific tourist sites are operational in the area, but it is expected that the Lekgalameetse Nature Reserve will become a tourist attraction in the near future. The improved road will also provide a direct access for tourists from Flag Boshielo area to Tzaneen and Phalaborwa. Economic activity in the region is being stimulated by gradual development of mining resources.

In 2003, the total annual average daily traffic (AADT) was about 285 vehicles in D4100, 380 in 4250, 380 in 4190, and 60 in D4050/D1583. The proportions of total traffic on the first three roads were 72% for mini-buses, 26% for passenger cars, and 2% for heavy goods vehicles. On the remaining road sections D4050/D1583, the total traffic was split equally between mini-buses and private passenger cars.

Passenger Cars

The initial levels of passenger car traffic in 2003 for sections D4100, D4250, D4190, D4050, D1583 were calculated from the total AADT counts multiplied by the estimated proportions of the traffic type. The average volumes of passenger car traffic on these segments were found to be 75, 100, 100, 30 and 30 vehicles per day in 2003.⁴ For later years the volume of passenger traffic on each segment is assumed to grow by 4.0% over the life of the project until 2027.⁵

Tourists

⁴ For instance, the share of passenger traffic on D4100 segment is 26%, and total AADT is 285. Then, the number of passenger cars is 75.

⁵ Over the past ten years since 2001, the annual GDP growth rate in South Africa was about 3.4%.

Tourist trips are expected to follow sections D4050 and D1583, starting in 2005 with AADT of 6. For the following years, the traffic is expected to rise annually by 4%.

Mini-Buses

The annual increase in mini-bus traffic is linked to the growth of passenger traffic, and the volume on all road segments rises by 4.0% per year. The initial AADT counts for sections D4100, D4250, D4190, D4050 and D1583 were estimated at 204, 272, 272, 30 and 30, respectively. The assumed 4.0% growth rate of passenger and mini-bus traffic is considered a conservative estimate of traffic volume.

Agriculture and Light Goods Vehicles

A number of small irrigation schemes are located within reach of the D4100 section. Most of these schemes are expected to become operational in the next four years as the Department of Agriculture completes rehabilitation and transfer of the affected properties to their farmowners. The improvement of the road will bring about reduced costs of transport. Agriculture and LGV traffic is expected to start in 2005 with AADT of 4.0. The future growth rate of agriculture and LGV on D4100 section is assumed to be 5.0%. On sections D4190 and 4250, the movement of LGV and agriculture transport will start in year 2005 with AADT of 4.0 and then gradually reach AADT of 6.0 in year 2007, thereafter a constant growth rate of 5.0% is assumed. No LGV and agriculture traffic is expected on sections D4050 and D1583.

Heavy Goods Vehicles

Most of HGV traffic on the proposed road is expected to originate from the irrigation schemes, which will be operational in the next few years. Agricultural produce grown on the farms will be transported to bigger towns of Polokwane, Lebwakhomo, and possibly Burgersfort. For the D4100 segment of the proposed road, the HGV traffic will most likely consist of agriculture transportation, plus a very few mining vehicles. In the absence of firm plans for mining development, it is difficult to predict what will be the additional mining HGV traffic volumes.

For this particular segment, the traffic volume is expected to gradually grow from AADT of 6.0 in 2003 to AADT of 15.0 in 2010, after which an annual growth rate of 5.0% is assumed. The possible construction of the Flag Boshielo dam wall would bring added traffic to this segment for two years, but no firm decision has been taken in this regard, this traffic is not included in the forecast.

On road sections D4250 and D4190, the 2003 count of 8.0 AADT is modeled to rise by a rate of 5.0% annually throughout the entire period of 2003-2027. No regular HGV traffic is expected on sections D4050 and D1583.

The traffic projections for the “without” project scenario over the life of the project are presented in Table 17.4.

Table 17.4: Projected Traffic by Road Section and Vehicle Type for “Without” Project Scenario (Number of AADT)

	D4100					D4250/D4190					D4050/D1583				Total
	Car	Mini-Bus	LGV/Agri	HGV	Sub-Total	Car	Mini-Bus	LGV/Agri	HGV	Sub-Total	Car	Tourist	Mini-Bus	Sub-Total	
2003	75	204	0	6	285	100	272	0	8	380	30	0	30	60	725
2004	78	212	0	6	296	104	283	0	8	395	31	6	31	68	760
2005	81	221	4	7	313	108	294	4	9	415	32	6	32	71	799
2006	84	229	4	9	327	112	306	5	9	433	34	6	34	74	833
2007	88	239	4	11	341	117	318	6	10	451	35	7	35	77	869
2008	91	248	5	12	356	122	331	6	10	469	36	7	36	80	906
2009	95	258	5	14	372	127	344	7	11	488	38	7	38	83	943
2010	99	268	5	15	387	132	358	7	11	508	39	8	39	87	982
2011	103	279	5	16	403	137	372	7	12	528	41	8	41	90	1021
2012	107	290	6	17	419	142	387	8	12	550	43	8	43	94	1062
2013	111	302	6	17	436	148	403	8	13	572	44	9	44	97	1105
2014	115	314	6	18	454	154	419	8	14	595	46	9	46	101	1150
2015	120	327	7	19	472	160	435	9	14	619	48	9	48	105	1196
2016	125	340	7	20	491	167	453	9	15	644	50	10	50	110	1245
2017	130	353	7	21	511	173	471	10	16	670	52	10	52	114	1295
2018	135	367	8	22	532	180	490	10	17	697	54	10	54	118	1347
2019	140	382	8	23	554	187	509	11	17	725	56	11	56	123	1402
2020	146	397	8	24	576	195	530	11	18	754	58	11	58	128	1459
2021	152	413	9	26	600	203	551	12	19	785	61	12	61	133	1518
2022	158	430	9	27	624	211	573	12	20	816	63	12	63	139	1579
2023	164	447	10	28	649	219	596	13	21	849	66	13	66	144	1643
2024	171	465	10	30	676	228	620	14	22	884	68	13	68	150	1709
2025	178	483	11	31	703	237	645	14	23	919	71	14	71	156	1778
2026	185	503	11	33	732	246	670	15	25	957	74	14	74	162	1850
2027	192	523	12	34	761	256	697	16	26	995	77	15	77	169	1925

17.5.2 Traffic Level With the Project

In addition to the above projected traffic levels for the “without project” scenario, there will be additional traffic, newly generated as a consequence of the project. The proposed road improvement is expected to result in a moderate volume of generated traffic, which would not have existed in the absence of the project.

Passenger Cars

It is assumed that passenger traffic diverted from other roads will start at level of 8 AADT on each of sections D4100, D4250 and D4190; and at level of 4 AADT on sections D4050 and D1583 in 2006. Thereafter, it is assumed to increase by 3.0% annually for passenger vehicles.

Generated passenger traffic starts at very low levels in 2006 with 4.0 AADT on D4100; in 2007 with 6.0 AADT on D4250/D4190; and in 2008 with 1.5 AADT on D4050/D1583. The annual growth rate of generated traffic on all sections is also assumed at 3.0%.

Tourists

The diverted tourist traffic is expected to use sections D4050 and D1583. The initial level of such traffic is projected to be 3.0 AADT in year 2006. The diverted passenger traffic will grow by 3.0% per year for the rest of forecast period. Generated tourist traffic is assumed to develop only on sections D4050 and D1583, with a starting level of 1.5 AADT in year 2008. It is projected to grow by 3.0% per year until 2027.

Mini-Buses

Diverted mini-bus traffic is assumed to begin in year 2006 at the level of 9.0 AADT on each of sections D4100, D4250 and D4190; and at the level of 6.0 AADT on sections D4050 and D1583. This traffic volume is expected to rise by a growth rate of 3.0% per annum. Generated mini-buses traffic is assumed to start in 2006 with 7.0 AADT on D4100; in 2007 with 8.0 AADT on D4250/D4190; and in 2008 with 1.5 AADT on D4050/D1583. The annual growth rate of generated traffic on all sections is assumed to be 3.0%.

Agriculture and Light Goods Vehicles

No substantial diverted traffic is expected on any of the sections for agriculture and light goods vehicle, but some users will be induced to use the improved road. This generated traffic will begin in 2006 with 1.0 AADT on D4100; and in 2007 with also 1.0 AADT on D4250/D4190. The annual growth rate of generated traffic on all sections is assumed to be 3.0%.

Heavy Goods Vehicles

Some diverted HGV traffic is assumed to begin in year 2006 at the level of 1.0 AADT on each of sections D4100, D4250 and D4190. This traffic volume will rise by the assumed growth rate of 3.0% per annum. A newly generated flow is expected to begin in 2006 with 1.0 AADT on D4100 and then gradually increase to the level of 1.75 AADT in 2009, after which it is projected to grow at a rate of 3.0% per annum. On sections D4250/D4190 the initial level of generated HGV volume is assumed to be 1.0 AADT; and its subsequent annual growth rate is taken as 3.0%.

With the above information, one can project the yearly average daily diverted and generated traffic over the life of the project resulted from the improvement of the project. The traffic volumes are presented in Tables 17.5 and 17.6 for “diverted” and “generated” traffic, respectively.

**Table 17.5: Projected “Diverted” Traffic by Road Section and Vehicle Type for “With” Project Scenario
(Number of AADT)**

	D4100				D4250/D4190				D4050/D1583				Total
	Car	Mini Bus	HGV	Sub-Total	Car	Mini Bus	HGV	Sub-Total	Car	Tourist	Mini Bus	Sub-Total	
2003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	8.0	9.0	1.0	18.0	8.0	9.0	1.0	18.0	4.0	3.0	6.0	13.0	49.0
2007	8.2	9.3	1.0	18.5	8.2	9.3	1.0	18.5	4.1	3.1	6.2	13.4	50.5
2008	8.5	9.5	1.1	19.1	8.5	9.5	1.1	19.1	4.2	3.2	6.4	13.8	52.0
2009	8.7	9.8	1.1	19.7	8.7	9.8	1.1	19.7	4.4	3.3	6.6	14.2	53.5
2010	9.0	10.1	1.1	20.3	9.0	10.1	1.1	20.3	4.5	3.4	6.8	14.6	55.1
2011	9.3	10.4	1.2	20.9	9.3	10.4	1.2	20.9	4.6	3.5	7.0	15.1	56.8
2012	9.6	10.7	1.2	21.5	9.6	10.7	1.2	21.5	4.8	3.6	7.2	15.5	58.5
2013	9.8	11.1	1.2	22.1	9.8	11.1	1.2	22.1	4.9	3.7	7.4	16.0	60.3
2014	10.1	11.4	1.3	22.8	10.1	11.4	1.3	22.8	5.1	3.8	7.6	16.5	62.1
2015	10.4	11.7	1.3	23.5	10.4	11.7	1.3	23.5	5.2	3.9	7.8	17.0	63.9
2016	10.8	12.1	1.3	24.2	10.8	12.1	1.3	24.2	5.4	4.0	8.1	17.5	65.9
2017	11.1	12.5	1.4	24.9	11.1	12.5	1.4	24.9	5.5	4.2	8.3	18.0	67.8
2018	11.4	12.8	1.4	25.7	11.4	12.8	1.4	25.7	5.7	4.3	8.6	18.5	69.9
2019	11.7	13.2	1.5	26.4	11.7	13.2	1.5	26.4	5.9	4.4	8.8	19.1	72.0
2020	12.1	13.6	1.5	27.2	12.1	13.6	1.5	27.2	6.1	4.5	9.1	19.7	74.1
2021	12.5	14.0	1.6	28.0	12.5	14.0	1.6	28.0	6.2	4.7	9.3	20.3	76.3
2022	12.8	14.4	1.6	28.9	12.8	14.4	1.6	28.9	6.4	4.8	9.6	20.9	78.6
2023	13.2	14.9	1.7	29.8	13.2	14.9	1.7	29.8	6.6	5.0	9.9	21.5	81.0
2024	13.6	15.3	1.7	30.6	13.6	15.3	1.7	30.6	6.8	5.1	10.2	22.1	83.4
2025	14.0	15.8	1.8	31.6	14.0	15.8	1.8	31.6	7.0	5.3	10.5	22.8	85.9
2026	14.4	16.3	1.8	32.5	14.4	16.3	1.8	32.5	7.2	5.4	10.8	23.5	88.5
2027	14.9	16.7	1.9	33.5	14.9	16.7	1.9	33.5	7.4	5.6	11.2	24.2	91.2

**Table 17.6: Projected “Generated” Traffic by Road Section and Vehicle Type for “With Project” Scenario
(Number of AADT)**

	D4100					D4250/D4190					D4050/D1583				Total
	Car	Mini Bus	LGV/ Agri	HGV	Sub-Total	Car	Mini Bus	LGV/ Agri	HGV	Sub-Total	Car	Tou-rist	Mini Bus	Sub-Total	
2003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0
2006	4.0	7.0	1.0	1.0	13.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	13.0
2007	4.1	7.2	1.0	1.3	13.6	6.0	8.0	1.0	1.0	16.0	0	0	0	0.0	29.6
2008	4.2	7.4	1.1	1.5	14.2	6.2	8.2	1.0	1.0	16.5	1.5	1.5	1.50	4.5	35.2
2009	4.4	7.6	1.1	1.8	14.9	6.4	8.5	1.1	1.1	17.0	1.5	1.5	1.55	4.6	36.5
2010	4.5	7.9	1.1	1.8	15.3	6.6	8.7	1.1	1.1	17.5	1.6	1.6	1.59	4.8	37.6
2011	4.6	8.1	1.2	1.9	15.8	6.8	9.0	1.1	1.1	18.0	1.6	1.6	1.64	4.9	38.7
2012	4.8	8.4	1.2	1.9	16.2	7.0	9.3	1.2	1.2	18.5	1.7	1.7	1.69	5.1	39.9
2013	4.9	8.6	1.2	2.0	16.7	7.2	9.6	1.2	1.2	19.1	1.7	1.7	1.74	5.2	41.0
2014	5.1	8.9	1.3	2.0	17.2	7.4	9.8	1.2	1.2	19.7	1.8	1.8	1.79	5.4	42.3
2015	5.2	9.1	1.3	2.1	17.7	7.6	10.1	1.3	1.3	20.3	1.8	1.8	1.84	5.5	43.5
2016	5.4	9.4	1.3	2.2	18.3	7.8	10.4	1.3	1.3	20.9	1.9	1.9	1.90	5.7	44.9
2017	5.5	9.7	1.4	2.2	18.8	8.1	10.8	1.3	1.3	21.5	2.0	2.0	1.96	5.9	46.2
2018	5.7	10.0	1.4	2.3	19.4	8.3	11.1	1.4	1.4	22.1	2.0	2.0	2.02	6.0	47.6
2019	5.9	10.3	1.5	2.4	20.0	8.6	11.4	1.4	1.4	22.8	2.1	2.1	2.08	6.2	49.0
2020	6.1	10.6	1.5	2.4	20.6	8.8	11.7	1.5	1.5	23.5	2.1	2.1	2.14	6.4	50.5
2021	6.2	10.9	1.6	2.5	21.2	9.1	12.1	1.5	1.5	24.2	2.2	2.2	2.20	6.6	52.0
2022	6.4	11.2	1.6	2.6	21.8	9.3	12.5	1.6	1.6	24.9	2.3	2.3	2.27	6.8	53.6
2023	6.6	11.6	1.7	2.6	22.5	9.6	12.8	1.6	1.6	25.7	2.3	2.3	2.34	7.0	55.2
2024	6.8	11.9	1.7	2.7	23.2	9.9	13.2	1.7	1.7	26.4	2.4	2.4	2.41	7.2	56.8
2025	7.0	12.3	1.8	2.8	23.9	10.2	13.6	1.7	1.7	27.2	2.5	2.5	2.48	7.4	58.5
2026	7.2	12.6	1.8	2.9	24.6	10.5	14.0	1.8	1.8	28.1	2.6	2.6	2.55	7.7	60.3
2027	7.4	13.0	1.9	3.0	25.3	10.8	14.4	1.8	1.8	28.9	2.6	2.6	2.63	7.9	62.1

17.6 Savings in Vehicle Operating Costs

Since the conditions of the existing road vary significantly among road sections, vehicle operating costs will also differ by section as well as by vehicle type.

Vehicle operating costs (VOC) include consumption of gasoline and oil, the wear-and-tear on tires, and the repair expenditures on vehicles. Their estimates for this project are based on the Roads Economic Decision (RED) model developed by the World Bank, and modified for South Africa by CSIR Transportek in 2003.⁶ Estimates are made by type of vehicle and by terrain, depending upon the degree of roughness of road, measured according to the International Roughness Index. The VOC is expressed as a function of the degree of road roughness (see Appendix 17A).

Since the original model's output was expressed in 2003 prices, VOCs for "with" and "without" project scenarios for different road sections were estimated by varying the degree of road roughness in the prices of 2003. The estimates were then adjusted by an annual inflation rate of 6.5% over the next two years to 2005 prices. For example, on section D4100 the VOC for private passenger cars was originally estimated from the RED model at R 3.261 per vehicle km in 2003 prices. This estimate applied to flat terrain in the absence of road improvement, and to a degree of road roughness measured at 10.0 (see Appendix 17A). The cost was then adjusted for inflation to become R 3.699 expressed in 2005 prices. After the road is upgraded from gravel to tarred surface, the road roughness is improved from the index 10.00 to index 2.0. The resulting VOC, re-estimated from the RED model and adjusted for inflation, was R 2.500 per vehicle km in 2005 prices.

The same procedure was used to estimate the average VOC per vehicle km for other vehicle types and other road sections. Estimates of the average VOC for each vehicle type traveling on

⁶Archondo-Callao, R., "Roads Economic Decision Model (RED) for Economic Evaluation of Low Volume Roads: Software Users Guide", Version 2.0, 3/15/01, the World Bank, Washington, D.C. The model was customized for South African conditions by CSIR Transportek at the request of the Development Bank of Southern Africa (DBSA). Available at <<http://www.dbsa.org>>.

each road section before and after the road improvement are presented in Table 17.7. These data provide the basis for our later estimates of total project-induced annual savings in vehicle operating costs.

**Table 17.7: Vehicle Operating Costs for “With” and “Without” Project Scenarios
(Rand per Vehicle km in 2005 Prices)**

Road Surface	Road Section	Car/ Tourists	Mini Buses	LGV/ Agriculture	HGV
Tarred (With Project)	D4100	2.500	3.065	3.770	6.050
	D4250/D4190	2.500	3.065	3.770	6.050
	D4050/D1583	2.833	3.443	4.569	8.160
Gravel (Without Project)	D4100	3.699	4.723	6.299	9.168
	D4250/D4190	3.699	4.723	6.299	9.168
	D4050/D1583	3.922	4.981	6.910	11.155

Sources: Details can be found in Appendix 17A.

17.7 Average Speeds of Vehicles

In addition to the vehicle operating costs, time cost of occupants travelling on the road can also be an important factor in the economic evaluation of the road improvement project. The time cost of the travellers can be determined by the speed of the vehicle and the time value of travellers. The former will be influenced by the condition of the road and the volume of the traffic while the latter is related to the wages and salaries of the driver and other occupants in the vehicle.

Since this project is located in a low traffic volume region (see Section 17.5), vehicle speed is unlikely to be affected by the volume of the traffic. Rather, the average vehicle speed is determined by the roughness of the road. As a consequence, the average vehicle speed measured in this project is based on the RED model developed by the World Bank, taking into consideration of the specific conditions in the Limpopo province of South Africa. Our speed estimates are for different vehicle types and various terrain and road conditions. As with the VOCs, speed is measured as a function of the degree of roughness.⁷ The estimating equations

⁷ Passenger cars and tourist traffic correspond to “car” class, mini-buses are linked to “light bus” class, LGV and agriculture transport are presumed to be in “light truck” class, while HGV corresponds to “heavy truck” class. The

used for each vehicle type were originally estimated for year 2003, and are shown in Appendix 17B.

The results are presented in Table 17.8. For example, without the road improvement the average vehicle speed for passenger cars traveling on the gravel road D4100 is 68.8km per hour, using an international roughness index of 10.0. With the road upgraded to a tarred surface, the roughness index is reduced to 2.0 and the vehicles can reach average speeds of 86.6 km per hour. This increase in vehicle speed, together with the value of time per hour allows us to estimate the value of project-induced time savings per vehicle km on D4100. The methodology for estimating the value of the vehicle-km for each vehicle type will be explained below.

Table 17.8: Average Speeds of Vehicles for “With” and “Without” Project Scenarios (Km per hour)

Road Surface	Road Section	Car/ Tourists	Mini Buses	LGV/ Agriculture	HGV
Tarred (With Project)	D4100	86.61	81.92	75.53	59.63
	D4250/D4190	86.61	81.92	75.53	59.63
	D4050/D1583	69.07	63.86	53.44	35.98
Gravel (Without Project)	D4100	68.76	60.44	53.88	45.07
	D4250/D4190	68.76	60.44	53.88	45.07
	D4050/D1583	60.71	53.64	44.83	31.62

Sources: Details can be found in Appendix 17B.

The next step is to estimate the average occupancy of each vehicle type and the time value per hour for its occupants. In regard to the average vehicle occupancy, a road user survey is used to obtain a reliable estimate. The time value of passengers is measured by wage rates for skilled and unskilled labor. For valuation of time saving for tourists, additional information is needed whether a particular tourist group is from overseas or domestic, and their respective average wage rates must be known.

speeds are estimated on a flat terrain with roughness index of 2.0 for tarred road, and on a flat terrain with the index of 10.0 for gravel road.

The information regarding vehicle occupancy and labor wage rates was obtained from the study by ARCUS GIBB.⁸ For passenger cars, an average rate of 1.2 skilled occupants is used. For tourist trips, it is assumed that there are, on the average, 1.5 tourists per vehicle and also on average 0.5 tourist guide per vehicle, thus making a total of 2.0 occupants per vehicle. For minibuses, 10.0 unskilled commuters comprise an average travel group. Note that for HGV, LGV and agriculture vehicles, the driver's salary is a direct cost of transportation and has already been accounted for as part of vehicle operating costs.

The wage rate for unskilled labor is taken as R 7.15 per hour, and the rate for skilled labor, it is R18.25 per hour.⁹ For tourists, who are likely to belong to the skilled category, only one half of their wage rate, R 9.13 per hour, is taken as value of time. For LGV, HGV and agriculture traffic, the value of time saving is dependent on the content and value of their cargo, and the respective value of delivery delays. Because of the wide diversity of agriculture, mining, and other goods that could be potentially traveling on the proposed road, they should be estimated separately, insofar as possible. The total time saving for each vehicle type can then be estimated.

For passenger cars, the value of time saving per vehicle-km is equal to the value of time per vehicle-km on the gravel road minus the value of time per vehicle-km on the tarred road. For example, on section D4100, the value of time per vehicle-km for a single occupant of a passenger car with a wage rate of R 18.25 per hour and traveling at the speed of 68.8 km per hour, is R 0.2654 per vehicle-km. With the same value of time, but traveling at a speed of 86.6 km per hour the time cost is R 0.2107 per vehicle-km. The estimated value of time saving for a passenger car is then about R 0.0656 per vehicle-km with 1.2 occupants. In a similar fashion, the value of time saving for passenger cars on sections D4250/D4190 and D4050/D1583 is estimated as R 0.0656 and R 0.0437 per vehicle-km, respectively.

⁸ ARCUS GIBB, "Limpopo Integrated Infrastructure Development Plan: Phase II – Benefit Cost Analysis of Selected Projects", Final Report, Appendix I: Flag Boshielo to Mafefe to Sekororo and Ga Seleka to Mmatladi, March 2004, from p. 4-2 to p. 4-3.

⁹ The study by ARCUS GIBB places values of R 6.71 and R 17.14 in 2004 on unskilled and skilled hourly wages, respectively. An inflation adjustment of 6.5% was applied to obtain the 2005 wage rates, resulting in R 7.15 and R 18.25.

For tourist trips on D4050/D1583 section, the estimated time saving per vehicle-km is R 0.0455. This is derived from the time saving for the average 1.5 tourists and 0.5 skilled occupants of a typical vehicle.¹⁰ No substantial volume of normal tourist traffic is expected on other sections of the upgraded road.

Min-Buses Traffic: The same method is applied to measure the value of time saving for mini-buses. For section D4100, the resulting estimate is R 0.3102 per vehicle-km.¹¹ The value of time savings for mini-bus traffic on sections D4250/D4190 and D4050/D1583 is estimated as R 0.3102 and R 0.2133 per vehicle-km, respectively.

In the case of freight for LGV and agriculture traffic, a different approach is needed to estimate the value of time saving. The improved road will allow LGV and agriculture transport to move at higher speed, which means a faster turnover of the vehicle fleet and more productive use of the vehicles. In the long run the owners of cargo will need fewer vehicles, thus resulting in savings of capital costs. Suppose a new truck costs R 1.30 million, its average utilization factor is 70%, and the real rates of depreciation and financial return on investment are 15.4% and 10.0% per annum, respectively.¹² On section D4100 alone, the value of time for LGV/agriculture traffic per vehicle-hour will be R 53.95.¹³ If the time saving per a 34-km trip due to speed increase is 0.181 hour, the value of capital savings can be estimated at R9.760 per vehicle-trip on this section.¹⁴

In addition to capital savings, there is also saving of driver's wages that will add up to R 1.294 per 34-km vehicle-trip.¹⁵ Thus, the combined value of time saving for heavy traffic is R 11.054

¹⁰ The value of time saving for tourists is equal to R 0.0273 per vehicle-km ($= [(R 9.13 / 60.7) - (R 9.13 / 69.1)] * 1.5$ occupants). For skilled occupants of a tourist vehicle, the estimated time saving amounts to R 0.0182 per vehicle-km ($= [(R 18.25 / 60.7) - (R 18.25 / 69.1)] * 0.5$ occupants). The summation of the value of time for both kinds of occupants gives us a figure of R 0.0455 per vehicle-km on section D4050/D1583.

¹¹ Estimated as $[(R 7.15 / 60.4) - (R 7.15 / 81.9)] * 10.0$ occupants = R 0.3102 per vehicle-km on section D4100.

¹² The average annual cost structure of truck transportation was obtained from the Vehicle Cost Schedule, published by the Road and Freight Association (October 2001).

¹³ The value of time for LGV vehicle is estimated as: $R 1,300,000 * (15.4\% + 10.0\%) / (365 * 24 * 70\%) = R 53.95$ per vehicle-hour. Alternatively, one can use annual rental charges for LGV vehicle divided by the number of hours the vehicle is actually transporting merchandise.

¹⁴ The amount of time saved per trip is equal to 0.181 hour per vehicle trip ($= 34 \text{ km} / 53.9 \text{ km/hr} - 34 \text{ km} / 75.5 \text{ km/hr}$). The value of capital savings can then be estimated as R 9.760 per vehicle trip ($= 53.95 \text{ R/hour} * 0.181 \text{ hour/vehicle-trip}$) on section D4100.

¹⁵ The value of driver's wage savings is estimated as: $R 7.15 \text{ hour} * 0.181 \text{ hour/vehicle-trip} = R 1.294$ per 34-km vehicle-trip.

per vehicle-trip on section D4100. Using the same approach, the value of time saving is estimated for sections D4250/D4190 and D4050/D1583 as R 15.281 for a length of 47 km and R 16.459 for 75 km per vehicle-trip, on the corresponding section.

17.8 Economic Appraisal

The economic appraisal of a project is concerned with the effect that the project has on the entire society and inquires whether the project increases the economic welfare of society as a whole. It looks at the present value of all the incremental annual economic benefits and costs generated throughout the project life, including savings in vehicle operating costs, time costs of travellers, maintenance costs, and other costs such as accidents and other externalities. The present value of annual benefits minus costs over the project's lifetime is then compared with the capital expenditures incurred on upgrading the road.

The annual savings in maintenance, VOC and time costs will be quantified in the next section. As regards the impacts of an improved road project on accidents, it could be important because of changes in the number of accidents and damages in monetary value on property and human bodies. In general, they should be properly assessed "with" and "without" project scenarios. This component, however, may not be significant in this project due to low volume traffic and it is therefore not included in this study.

Other externalities such as various taxes and subsidies involved in key project inputs are captured in Commodity Specific Conversion Factors (CSCF). Three key CSCFs are identified in this project. They are infrastructure construction and maintenance costs, truck transportation, and passenger care transportation; and their corresponding CSCFs are estimated at 0.876, 0.850, and 0.922, respectively, based on methodology outlined in Chapter 11 and the empirical estimation carried out elsewhere.¹⁶ These CSCFs allow us to convert all financial costs of the project inputs into the corresponding economic costs in order to construct the economic resource flow statement of the project.

¹⁶ Taken from Cambridge Resources International, "Integrated Investment Appraisal: Concepts and Practice", *Appendix G: Commodity-Specific Conversion Factors for Non-Tradable Goods and Services in South Africa*, (2004).

17.8.1 Annual Savings in Maintenance Costs, VOC and Time Costs

This section summarizes total savings in maintenance costs, vehicle operating costs and time costs generated by upgrading the gravel road to the tarred road.

Maintenance Costs

Annual savings in financial maintenance costs have been estimated (costs with the project minus what they would have been in its absence) and are presented in Table 17.3 by road section. These costs are multiplied by the conversion factor for maintenance costs at 0.876 to generate annual savings of economic resource costs. Details for each year over the life of the project are shown in Table 17.9 by road section and by frequency of maintenance.

A positive result means that some cost savings will be generated, while negatives imply a net increase in resource costs. In this case, each type of maintenance activity will generate savings in economic resource costs. The estimated present value of these savings (using the economic cost of capital for South Africa at 11.0% as the discount rate¹⁷) due to road improvement amounts to R 137.8 million in 2005 prices. About 57.1% of the total savings stems from reduced costs of intermediate maintenance. Savings in periodic maintenance account for 35.7% of the total, and savings on routine maintenance account for the remaining 7.2%.

¹⁷Kuo, C.Y., Jenkins, G.P., and Mphahlele, M.B., "The Economic Opportunity Cost of Capital in South Africa", *South African Journal of Economics*, Vol. 71:3, (September 2003), pp. 525-543.

**Table 17.9: Savings in Economic Maintenance Costs
(Millions of Rand in 2005 Prices)**

Year	Routine					Intermediate					Periodic					Total
	D 4100	D 4250	D 4190	D 4050/ D 1583	Sub-Total	D 4100	D 4250	D 4190	D 4050/ D 1583	Sub-Total	D 4100	D 4250	D 4190	D 4050/ D 1583	Sub-Total	
2005	1.11	0.65	0.00	0.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.76
2006	0.16	0.32	0.65	0.82	1.95	6.34	5.04	3.73	13.99	29.11	0.00	0.00	0.00	0.00	0.00	31.06
2007	0.16	0.13	0.09	1.75	2.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.13
2008	0.16	0.13	0.09	0.35	0.73	1.59	2.24	3.73	13.99	21.55	0.00	0.00	0.00	0.00	0.00	22.28
2009	0.16	0.13	0.09	0.35	0.73	0.00	-0.98	-2.80	-3.50	-7.28	11.10	8.82	6.53	24.49	50.94	44.39
2010	0.16	0.13	0.09	0.35	0.73	6.34	5.04	3.73	7.00	22.11	0.00	0.00	0.00	0.00	0.00	22.84
2011	0.16	0.13	0.09	0.35	0.73	-4.76	-2.80	0.00	0.00	-7.56	0.00	0.00	0.00	0.00	0.00	-6.83
2012	0.16	0.13	0.09	0.35	0.73	6.34	4.06	0.93	10.50	21.83	0.00	0.00	0.00	0.00	0.00	22.56
2013	0.16	0.13	0.09	0.35	0.73	0.00	0.00	0.00	-7.00	-7.00	0.00	0.00	0.00	0.00	0.00	-6.27
2014	0.16	0.13	0.09	0.35	0.73	1.59	2.24	3.73	13.99	21.55	11.10	8.82	6.53	24.49	50.94	73.22
2015	0.16	0.13	0.09	0.35	0.73	0.00	-0.98	-2.80	-3.50	-7.28	-15.86	-9.33	0.00	0.00	-25.19	-31.74
2016	0.16	0.13	0.09	0.35	0.73	6.34	5.04	3.73	7.00	22.11	0.00	-3.27	-9.33	-11.66	-24.26	-1.42
2017	0.16	0.13	0.09	0.35	0.73	-4.76	-2.80	0.00	0.00	-7.56	0.00	0.00	0.00	-23.32	-23.32	-30.15
2018	0.16	0.13	0.09	0.35	0.73	6.34	4.06	0.93	10.50	21.83	0.00	0.00	0.00	0.00	0.00	22.56
2019	0.16	0.13	0.09	0.35	0.73	0.00	0.00	0.00	-7.00	-7.00	11.10	8.82	6.53	24.49	50.94	44.67
2020	0.16	0.13	0.09	0.35	0.73	1.59	2.24	3.73	13.99	21.55	0.00	0.00	0.00	0.00	0.00	22.28
2021	0.16	0.13	0.09	0.35	0.73	0.00	-0.98	-2.80	-3.50	-7.28	0.00	0.00	0.00	0.00	0.00	-6.55
2022	0.16	0.13	0.09	0.35	0.73	6.34	5.04	3.73	7.00	22.11	0.00	0.00	0.00	0.00	0.00	22.84
2023	0.16	0.13	0.09	0.35	0.73	-4.76	-2.80	0.00	0.00	-7.56	0.00	0.00	0.00	0.00	0.00	-6.83
2024	0.16	0.13	0.09	0.35	0.73	6.34	4.06	0.93	10.50	21.83	11.10	8.82	6.53	24.49	50.94	73.50
2025	0.16	0.13	0.09	0.35	0.73	0.00	0.00	0.00	-7.00	-7.00	0.00	0.00	0.00	0.00	0.00	-6.27
2026	0.16	0.13	0.09	0.35	0.73	1.59	2.24	3.73	13.99	21.55	0.00	0.00	0.00	0.00	0.00	22.28
2027	0.16	0.13	0.09	0.35	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73
PV@11%	2.4	1.9	1.3	4.4	9.9	15.8	12.9	10.2	39.8	78.7	10.2	8.2	6.3	24.4	49.1	137.75

Vehicle Operating Costs

Given the estimates of savings in VOC and time cost per vehicle km by vehicle type presented in Sections 17.6 and 17.7 and the projected corresponding annual normal, diverted, and generated traffic on each road section shown in Section 17.5, we can estimate annual saving in vehicle operating costs and time costs for each road section and then aggregate to total annual savings. These incremental financial cost savings are translated into incremental economic resource savings by applying economic conversion factors for each type of outlay.

Vehicle operating costs constitute a major expense for road users. Using gravel roads increase VOC costs substantially for all vehicle types. These costs will decline as a consequence of the upgrading of the road. The cost savings or the economic benefits to the existing or normal traffic are the summation of savings in VOCs per km multiplied by the AADT on the road section, the length of the road, and 365 days a year over all types of vehicle. The resulting values are multiplied by the relevant conversion factor at 0.850 for LGV, HGV, and agricultural transport and 0.922 for cars, tourists, and mini-buses.

For the “diverted” and “generated” traffic, the total benefits are measured by one-half of the per-unit reduction in the above VOC costs per vehicle km times the length of travel and the total diverted and generated traffic over 365 days a year.

It may be noted that because the construction takes 3 years to complete, an adjustment is made to exclude each length of sections until it is upgraded, and to treat VOC on these sections as traffic on gravel road. During the construction period of a particular section, no VOC savings are materialized since the traffic typically uses a temporary by-pass.

Table 17.10 presents annual savings in VOC for traffic that would be present even without the project. The present value of economic VOC resource savings is estimated to be 200.8 million Rand in 2005 prices. This result is a significant addition to savings in maintenance costs. For diverted and generated traffic by various types of vehicle, the VOC savings are estimated to be approximately 5.9 million and 3.8 million Rand, respectively.

**Table 17.10: VOC Savings for Normal Traffic
(millions of Rand in 2005 Prices)**

Year	D4100					D4250/D4190					D4050/D1583				Total
	Car	Mini Bus	LGV/ Agri	HGV	Sub-Total	Car	Mini Bus	LGV/ Agri	HGV	Sub-Total	Car	Tourist	Mini Bus	Sub-Total	
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	1.2	4.4	0.1	0.3	5.9	0.9	3.4	0.1	0.2	4.6	0.0	0.0	0.0	0.0	10.5
2007	1.2	4.5	0.1	0.3	6.2	2.2	8.3	0.2	0.4	11.2	0.3	0.1	0.5	0.8	18.3
2008	1.3	4.7	0.1	0.4	6.5	2.3	8.7	0.2	0.5	11.7	1.0	0.2	1.4	2.6	20.8
2009	1.3	4.9	0.1	0.5	6.8	2.4	9.0	0.2	0.5	12.2	1.0	0.2	1.5	2.7	21.7
2010	1.4	5.1	0.1	0.5	7.1	2.5	9.4	0.3	0.5	12.6	1.1	0.2	1.5	2.8	22.5
2011	1.4	5.3	0.1	0.5	7.4	2.6	9.8	0.3	0.5	13.2	1.1	0.2	1.6	2.9	23.5
2012	1.5	5.5	0.2	0.5	7.7	2.7	10.1	0.3	0.6	13.7	1.2	0.2	1.7	3.1	24.4
2013	1.5	5.7	0.2	0.6	8.0	2.8	10.6	0.3	0.6	14.3	1.2	0.2	1.7	3.2	25.4
2014	1.6	6.0	0.2	0.6	8.3	2.9	11.0	0.3	0.6	14.8	1.3	0.2	1.8	3.3	26.4
2015	1.6	6.2	0.2	0.6	8.6	3.0	11.4	0.3	0.7	15.4	1.3	0.3	1.9	3.4	27.5
2016	1.7	6.4	0.2	0.7	9.0	3.2	11.9	0.3	0.7	16.1	1.4	0.3	1.9	3.6	28.6
2017	1.8	6.7	0.2	0.7	9.4	3.3	12.3	0.4	0.7	16.7	1.4	0.3	2.0	3.7	29.8
2018	1.9	7.0	0.2	0.7	9.8	3.4	12.8	0.4	0.8	17.4	1.5	0.3	2.1	3.9	31.0
2019	1.9	7.2	0.2	0.8	10.1	3.6	13.4	0.4	0.8	18.1	1.5	0.3	2.2	4.0	32.3
2020	2.0	7.5	0.2	0.8	10.6	3.7	13.9	0.4	0.8	18.8	1.6	0.3	2.3	4.2	33.6
2021	2.1	7.8	0.2	0.8	11.0	3.8	14.4	0.4	0.9	19.6	1.7	0.3	2.4	4.4	35.0
2022	2.2	8.2	0.2	0.9	11.4	4.0	15.0	0.5	0.9	20.4	1.7	0.3	2.5	4.5	36.4
2023	2.3	8.5	0.3	0.9	11.9	4.2	15.6	0.5	1.0	21.2	1.8	0.3	2.6	4.7	37.9
2024	2.3	8.8	0.3	1.0	12.4	4.3	16.2	0.5	1.0	22.1	1.9	0.4	2.7	4.9	39.4
2025	2.4	9.2	0.3	1.0	12.9	4.5	16.9	0.5	1.1	23.0	2.0	0.4	2.8	5.1	41.0
2026	2.5	9.5	0.3	1.1	13.4	4.7	17.6	0.6	1.1	23.9	2.0	0.4	2.9	5.3	42.7
2027	2.6	9.9	0.3	1.1	14.0	4.9	18.3	0.6	1.2	24.9	2.1	0.4	3.0	5.5	44.4

Time Savings

The value of time saving is determined by an increase in vehicle speed, the length of road section, and the time value of each occupant traveling or the time value of the vehicles used to transport merchandise plus the time value of the cargo. The speed of each type of vehicle traveling on different road section was estimated for the “with” and “without” project scenarios, leading to consequent estimates of savings in time cost per vehicle km. Like the reduced VOC costs, road users of normal traffic will experience a rise in their average speed on the improved road, thus saving in full amount of travel time. In the case of diverted and generated traffic, the benefits are measured by one-half of time saved between traveling in the upgraded tarred road and the gravel road.

Once the value of time savings per vehicle-km and per vehicle-trip are estimated for all vehicle types and road sections, a combined annual statement in time saving for the existing traffic and consumer surplus for diverted and generated traffic can be estimated. The total annual benefits in time savings for all normal traffic over the life of the project are presented in Table 17.11. Their present value over the life of the project amounts to 33.11 million Rand in 2005 prices. The time savings for diverted and generated are 0.59 million and 0.46 million Rand, respectively.

Table 17.11: Time Savings for Normal Traffic
(Millions of Rand in 2005 Prices)

Year	D4100					D4250/D4190					D4050/D1583				Total
	Car	Mini Bus	LGV/ Agri	HGV	Sub-Total	Car	Mini Bus	LGV/ Agri	HGV	Sub-Total	Car	Tourist	Mini Bus	Sub-Total	
2005	0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.0
2006	0.1	0.9	0.02	0.1	1.0	0.1	0.7	0.01	0.0	0.8	0.0	0.00	0.0	0.0	1.8
2007	0.1	0.9	0.02	0.1	1.1	0.1	1.7	0.03	0.1	1.9	0.0	0.00	0.1	0.1	3.1
2008	0.1	1.0	0.02	0.1	1.1	0.1	1.8	0.04	0.1	2.0	0.0	0.01	0.2	0.3	3.4
2009	0.1	1.0	0.02	0.1	1.2	0.1	1.8	0.04	0.1	2.1	0.0	0.01	0.2	0.3	3.6
2010	0.1	1.0	0.02	0.1	1.2	0.1	1.9	0.04	0.1	2.2	0.0	0.01	0.2	0.3	3.7
2011	0.1	1.1	0.02	0.1	1.3	0.2	2.0	0.04	0.1	2.3	0.0	0.01	0.2	0.3	3.8
2012	0.1	1.1	0.02	0.1	1.3	0.2	2.1	0.04	0.1	2.4	0.1	0.01	0.2	0.3	4.0
2013	0.1	1.2	0.02	0.1	1.4	0.2	2.1	0.04	0.1	2.5	0.1	0.01	0.3	0.3	4.2
2014	0.1	1.2	0.03	0.1	1.4	0.2	2.2	0.05	0.1	2.6	0.1	0.01	0.3	0.3	4.3
2015	0.1	1.3	0.03	0.1	1.5	0.2	2.3	0.05	0.1	2.7	0.1	0.01	0.3	0.3	4.5
2016	0.1	1.3	0.03	0.1	1.6	0.2	2.4	0.05	0.1	2.8	0.1	0.01	0.3	0.4	4.7
2017	0.1	1.4	0.03	0.1	1.6	0.2	2.5	0.05	0.1	2.9	0.1	0.01	0.3	0.4	4.9
2018	0.1	1.4	0.03	0.1	1.7	0.2	2.6	0.06	0.1	3.0	0.1	0.01	0.3	0.4	5.1
2019	0.1	1.5	0.03	0.1	1.8	0.2	2.7	0.06	0.1	3.1	0.1	0.01	0.3	0.4	5.3
2020	0.1	1.5	0.03	0.1	1.8	0.2	2.8	0.06	0.2	3.3	0.1	0.01	0.3	0.4	5.5
2021	0.1	1.6	0.04	0.2	1.9	0.2	2.9	0.07	0.2	3.4	0.1	0.01	0.4	0.4	5.7
2022	0.1	1.7	0.04	0.2	2.0	0.2	3.0	0.07	0.2	3.5	0.1	0.02	0.4	0.5	6.0
2023	0.1	1.7	0.04	0.2	2.1	0.2	3.2	0.07	0.2	3.7	0.1	0.02	0.4	0.5	6.2
2024	0.1	1.8	0.04	0.2	2.1	0.3	3.3	0.08	0.2	3.8	0.1	0.02	0.4	0.5	6.5
2025	0.1	1.9	0.04	0.2	2.2	0.3	3.4	0.08	0.2	4.0	0.1	0.02	0.4	0.5	6.7
2026	0.2	1.9	0.04	0.2	2.3	0.3	3.6	0.08	0.2	4.1	0.1	0.02	0.4	0.5	7.0
2027	0.2	2.0	0.05	0.2	2.4	0.3	3.7	0.09	0.2	4.3	0.1	0.02	0.4	0.6	7.3

17.8.2 Economic Viability of the Project

The economic viability of the project is based on the incremental economic benefits and costs generated throughout the entire life of the project. The main incremental annual economic benefits are savings in maintenance costs, vehicle operating costs and time costs. These were presented in the previous section, and are summarized in Columns 3 to 5 of Table 17.12. The savings expressed in the present value are R 137.8 million, R 210.5 million, and R 34.2 million, respectively, using the real economic cost of capital for South Africa (11%) as the discount rate.

The major cost of this improved road project is the construction cost incurred by RAL. After conversion into economic cost, its present value is R 277.2 million in 2005 prices. This is the economic opportunity cost of resources that are employed to upgrade the road. The Roads Agency of Limpopo is not going to gain financially from this project, because the estimated value of its resource savings due to reduced maintenance activities alone (R 137.8 million) falls far short of the proposed investment (R 277.2 million). However, apart from the RAL, other stakeholders are involved and their net benefits can easily carry the project to a positive overall net present value.

Once economic costs and benefits are estimated on an annual basis, an economic resource flow statement is developed. This statement presents the projected incremental economic investment costs along with the value of generated incremental economic benefits in order to obtain the net resource flow generated by the proposed road improvement. The annual economic resource flow statement shown in Table 17.12 summarizes the investment costs, economic maintenance resource cost savings, economic VOC savings, and time savings. The estimated economic net present value of the whole project is R 105.2 million at 2005 prices, using an 11% discount rate. This positive economic NPV implies that the country as a whole is better off with the proposed project. The ratio of PV of benefits to the PV of costs is 1.38.

**Table 17.12: Economic Resource Flow Statement
(Millions of Rand in 2005 Prices)**

	Construction Costs	Savings in Maintenance cost	Savings in VOC	Savings in Time Costs	Total
2005	-100.5	1.8	0.0	0.0	-98.8
2006	-102.3	31.1	11.2	1.9	-58.2
2007	-104.1	2.1	19.2	3.2	-79.6
2008	0	22.3	21.8	3.5	47.6
2009	0	44.4	22.7	3.7	70.8
2010	0	22.8	23.7	3.8	50.3
2011	0	-6.8	24.6	4.0	21.8
2012	0	22.6	25.6	4.1	52.3
2013	0	-6.3	26.6	4.3	24.7
2014	0	73.2	27.7	4.5	105.4
2015	0	-31.7	28.8	4.7	1.7
2016	0	-1.4	30.0	4.8	33.4
2017	0	-30.2	31.2	5.0	6.1
2018	0	22.6	32.4	5.2	60.2
2019	0	44.7	33.7	5.5	83.9
2020	0	22.3	35.1	5.7	63.0
2021	0	-6.5	36.5	5.9	35.8
2022	0	22.8	38.0	6.1	66.9
2023	0	-6.8	39.5	6.4	39.1
2024	0	73.5	41.1	6.6	121.2
2025	0	-6.3	42.7	6.9	43.4
2026	0	22.3	44.5	7.2	73.9
2027	0	0.7	46.2	7.5	54.5
PV@11%	-277.2	137.8	210.5	34.2	105.2

It is important to note that the proposed road is composed of three separate sections that are, in fact, projects on their own since they have different construction costs and provide different levels of benefits. The analysis can be structured in such a way to evaluate the economic feasibility of each section of the road.

Following the same approach as outlined previously, the net economic benefits were found to equal R 94.5 million for upgrading D4250/D4190 due to substantial VOC savings. Section D4100 also exhibits a positive economic NPV of R 45.7 million, while section D4050/D1583 generates a negative economic NPV of R 35.0 million. In other words, section D4050/D1583 should be excluded from the upgrade plan at this point in time. In so doing, the benefits

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generated from the overall project would rise to R 140.2 million from R 105.2 million. Details can be found in Table 17.13.

Table 17.13: Economic Resource Flow Statement by Road Section
(millions of Rand in 2005 Prices)

Year	Section D4100					Section D4250/D4190					Section D4050/D1583					Total
	Construct- ion Costs	Savings in Maintenance Costs	Savings in VOC	Savings in Time Costs	Sub- Total	Construct- ion Costs	Savings in Maintenance Costs	Savings in VOC	Savings in Time Costs	Sub- Total	Construct- ion Costs	Savings in Maintenance Costs	Savings in VOC	Savings in Time Costs	Sub- Total	
2005	-63.3	1.11	0.00	0.00	-62.2	-37.2	0.65	0.00	0.00	-36.6	0.0	0.00	0.00	0.00	0.0	-98.8
2006	0.0	6.50	6.19	1.07	13.8	-50.2	9.74	4.80	0.82	-34.9	-52.1	14.81	0.21	0.01	-37.1	-58.2
2007	0.0	0.16	6.49	1.12	7.8	0.0	0.22	11.65	1.99	13.9	-104.1	1.75	1.06	0.10	101.2	-79.6
2008	0.0	1.74	6.80	1.17	9.7	0.0	6.19	12.12	2.07	20.4	0.0	14.34	2.91	0.28	17.5	47.6
2009	0.0	11.26	7.11	1.23	19.6	0.0	11.79	12.61	2.15	26.6	0.0	21.34	3.02	0.29	24.7	70.8
2010	0.0	6.50	7.41	1.28	15.2	0.0	8.99	13.12	2.24	24.3	0.0	7.35	3.14	0.30	10.8	50.3
2011	0.0	-4.60	7.71	1.33	4.4	0.0	-2.58	13.65	2.33	13.4	0.0	0.35	3.26	0.31	3.9	21.8
2012	0.0	6.50	8.02	1.38	15.9	0.0	5.21	14.19	2.43	21.8	0.0	10.85	3.39	0.33	14.6	52.3
2013	0.0	0.16	8.34	1.44	9.9	0.0	0.22	14.77	2.52	17.5	0.0	-6.65	3.52	0.34	-2.8	24.7
2014	0.0	12.85	8.68	1.50	23.0	0.0	21.54	15.36	2.62	39.5	0.0	38.83	3.66	0.35	42.8	105.4
2015	0.0	-15.70	9.03	1.56	-5.1	0.0	-12.89	15.98	2.73	5.8	0.0	-3.15	3.80	0.37	1.0	1.7
2016	0.0	6.50	9.39	1.62	17.5	0.0	-3.61	16.62	2.84	15.9	0.0	-4.31	3.95	0.38	0.0	33.4
2017	0.0	-4.60	9.77	1.69	6.9	0.0	-2.58	17.29	2.96	17.7	0.0	-22.97	4.11	0.40	-18.5	6.1
2018	0.0	6.50	10.17	1.75	18.4	0.0	5.21	17.99	3.08	26.3	0.0	10.85	4.27	0.41	15.5	60.2
2019	0.0	11.26	10.58	1.83	23.7	0.0	15.57	18.71	3.20	37.5	0.0	17.84	4.43	0.43	22.7	83.9
2020	0.0	1.74	11.01	1.90	14.7	0.0	6.19	19.47	3.33	29.0	0.0	14.34	4.61	0.44	19.4	63.0
2021	0.0	0.16	11.46	1.98	13.6	0.0	-3.56	20.25	3.46	20.2	0.0	-3.15	4.79	0.46	2.1	35.8
2022	0.0	6.50	11.92	2.06	20.5	0.0	8.99	21.07	3.60	33.7	0.0	7.35	4.97	0.48	12.8	66.9
2023	0.0	-4.60	12.41	2.14	9.9	0.0	-2.58	21.92	3.75	23.1	0.0	0.35	5.17	0.50	6.0	39.1
2024	0.0	17.60	12.91	2.23	32.7	0.0	20.56	22.80	3.90	47.3	0.0	35.34	5.37	0.52	41.2	121.2
2025	0.0	0.16	13.43	2.32	15.9	0.0	0.22	23.72	4.06	28.0	0.0	-6.65	5.58	0.54	-0.5	43.4
2026	0.0	1.74	13.98	2.41	18.1	0.0	6.19	24.68	4.22	35.1	0.0	14.34	5.80	0.56	20.7	73.9
2027	0.0	0.16	14.55	2.51	17.2	0.0	0.22	25.68	4.39	30.3	0.0	0.35	6.03	0.58	7.0	54.5
PV@11%	-63.3	28.4	68.8	11.9	45.7	-82.5	40.7	116.3	19.9	94.5	-131.5	68.6	25.4	2.4	-35.0	105.2

17.9 Impact on Stakeholders

The measurement of project costs and the economic analysis of the project provide the basic data for assessing the impacts of the project on various stakeholders. The analysis looks into the financial expenditures incurred by Road Agency and the allocation of project externalities among the stakeholders affected by the road improvement.

The stakeholders identified in the analysis are divided into two groups: the Roads Agency of Limpopo (RAL) and various road users. The road users are further divided into existing road users that will continue driving on the road even in the absence of upgrading the road, diverted users who will switch to the upgraded road from other road or alternative transportation modes, and newly generated traffic that will be induced to the road when it is upgraded. There are five vehicle classes in each traffic flow --passenger cars, tourists, mini-buses, light goods vehicles and agriculture transport, and heavy goods vehicles.

Table 17.14 presents a summary of economic benefits accruing to each stakeholder. For the Road Agency, it will incur the initial capital expenditure of R 277.2 million to upgrade the gravel to tarred road. With such an investment, there is a substantial amount of savings in maintenance costs for the Agency (equal to a present value of R 137.8 million). As a result, the net cost to the Agency would be R 139.4 million.

The present value of total economic net benefits created by the project is R 382.5 million, with 36.0% of that amount accruing to the Road Agency in the form of maintenance resource cost savings. The rest is spread across the different road users, notably to the owners of mini-buses (46.2%), passenger cars (12.8%), HGV (3.2%), tourists (0.6%), and LGV/agriculture transport (1.2%).

Another facet of the distributional analysis considers the allocation of benefits among the existing, diverted, and generated road users. Out of the total benefits of R 244.7 million, the existing road users stand to gain an amount of R 234.0 million, almost 96% of the total net

economic benefits. The diverted vehicles will benefit marginally by an amount of R 6.6 million, and generated traffic will gain R 4.3 million.

**Table 17.14: Allocation of Costs and Benefits
(millions of Rand in 2005 Prices)**

Stakeholders	Category	Costs	Benefits	Percentage Distribution
Road Agency	Investment Costs	-277.2		36.0%
	Savings in Maintenance Costs:			
	Routine		9.9	
	Intermediate		78.7	
	Periodic		49.1	
	Sub-Total		137.8	
Car Passengers	Existing		45.9	12.8%
	Diverted		2.0	
	Generated		1.0	
	Sub-Total		48.8	
Tourists	Existing		1.8	0.6%
	Diverted		0.4	
	Generated		0.2	
	Sub-Total		2.3	
Mini Buses	Existing		171.1	46.2%
	Diverted		3.7	
	Generated		2.1	
	Sub-Total		176.9	
LGV/Agriculture	Existing		4.2	1.2%
	Diverted		0.0	
	Generated		0.4	
	Sub-Total		4.6	
HGV	Existing		11.0	3.2%
	Diverted		0.5	
	Generated		0.6	
	Sub-Total		12.1	
Total		-277.2	382.5	100.0%

17.10 Dealing with Risk

The above analysis represents the most likely single estimates of various variables used in the upgrading of the road. The impacts of the project on the economic outcomes and stakeholders become point estimates. If the values of these variables change over the life of the project, so will the project outcomes. Reorganizing this, and to help decision-makers, we conduct sensitivity and risk analyses of the project.

17.10.1 Sensitivity Analysis

A sensitivity analysis is conducted to assess the impact of several key input variables on the economic outcomes and stakeholders of the project. It is carried out by changing the value of one of these parameters at a time over the range of possible values and examining the impact this has on the project outcomes.

Costs Overrun

Capital cost overruns are quite possible and can have a significant negative impact on the outcome of the project. The effect of capital cost overrun on a range from -10% to +40% is shown in Table 17.15. The economic NPV is very sensitive to changes in construction costs. A 10% increase in investment costs results in a more than 26% drop in the project's economic NPV. If actual construction costs increase more than approximately 38%, the project's economic NPV turns negative and thus the project is not economically viable.

The impact of cost overruns falls on the Road Agency alone. There may be some externalities generated by those who work on the construction phase. However, they would be small and are ignored here.

Table 17.15: Sensitivity Test of Capital Cost Overrun
(millions of Rand in 2005 Prices)

Cost Overruns	Economic NPV	Impacts on Stakeholders					
		RAL	Car	Tourist	Mini Bus	LGV/Agri	HGV
-10%	132.9	-111.8	48.8	2.3	176.9	4.6	12.1
-5%	119.1	-125.6	48.8	2.3	176.9	4.6	12.1
0%	105.2	-139.5	48.8	2.3	176.9	4.6	12.1
5%	91.4	-153.3	48.8	2.3	176.9	4.6	12.1
10%	77.5	-167.2	48.8	2.3	176.9	4.6	12.1
15%	63.6	-181.1	48.8	2.3	176.9	4.6	12.1
20%	49.8	-194.9	48.8	2.3	176.9	4.6	12.1
25%	35.9	-208.8	48.8	2.3	176.9	4.6	12.1
30%	22.1	-222.6	48.8	2.3	176.9	4.6	12.1
35%	8.2	-236.5	48.8	2.3	176.9	4.6	12.1
40%	-5.7	-250.4	48.8	2.3	176.9	4.6	12.1

Initial AADT Level

The traffic projection model is based on 2003 traffic counts, which may not be very precise estimates of the current traffic volume. A sensitivity test is performed to check whether the initial AADT counts would affect the project's economic NPV if changed over a range from -50% to +50% of the base case. A 10% decrease in the values of the initial AADTs leads to a 21% decline in the economic NPV. If the actual traffic flow is less than the base case assumption by approximately 48%, the economic NPV turns negative.

The main impacts of changes in the initial AADT counts on stakeholders are private car passengers, mini buses, and HGV. Table 17.16 shows the results of this sensitivity test.

**Table 17.16: Sensitivity Test of the Initial AADT Levels
(millions of Rand in 2005 Prices)**

Initial AADT Levels	Economic NPV	Impacts on Stakeholders					
		RAL	Car	Tourist	Mini Bus	LGV/Agri	HGV
-50%	-6.1	-139.5	25.9	2.3	91.3	4.6	9.3
-40%	16.2	-139.5	30.5	2.3	108.4	4.6	9.8
-30%	38.5	-139.5	35.0	2.3	125.5	4.6	10.4
-20%	60.7	-139.5	39.6	2.3	142.6	4.6	11.0
-10%	83.0	-139.5	44.2	2.3	159.8	4.6	11.5
0%	105.2	-139.5	48.8	2.3	176.9	4.6	12.1
10%	127.5	-139.5	53.4	2.3	194.0	4.6	12.6
20%	149.7	-139.5	58.0	2.3	211.1	4.6	13.2
30%	172.0	-139.5	62.6	2.3	228.2	4.6	13.8
40%	194.3	-139.5	67.2	2.3	245.3	4.6	14.3
50%	216.5	-139.5	71.7	2.3	262.4	4.6	14.9

Traffic Growth Rate

This test measures the project's performance under alternative rates of growth in the volume of traffic (ranging from -1% to +6%). The higher the growth rate, the greater the benefits received by road users, especially mini buses and private car passengers. A one percentage point increase in growth rate would raise the economic benefits by more than 26%. Table 17.17 shows detailed results of this sensitivity test.

It should be noted that a higher traffic level in this sensitivity analysis does not result in an increased frequency and cost of road maintenance. This explains why the present value of net benefits accruing to the RAL remains unchanged.

Table 17.17: Sensitivity Test of Traffic Growth Rates
(millions of Rand in 2005 Prices)

Traffic Growth Rate	Economic NPV	Impacts on Stakeholders					
		RAL	Car	Tourist	Mini Bus	LGV/Agri	HGV
-1.0%	81.2	-139.5	43.9	2.3	159.0	4.3	11.2
-0.5%	92.8	-139.5	46.3	2.3	167.7	4.4	11.6
0.0%	105.2	-139.5	48.8	2.3	176.9	4.6	12.1
1.0%	132.6	-139.5	54.4	2.4	197.2	5.0	13.1
2.0%	163.7	-139.5	60.8	2.4	220.3	5.4	14.3
3.0%	199.2	-139.5	68.1	2.5	246.6	5.9	15.6
4.0%	239.8	-139.5	76.4	2.6	276.8	6.4	17.1
5.0%	286.2	-139.5	85.9	2.6	311.3	7.0	18.7
6.0%	339.4	-139.5	96.8	2.7	350.9	7.7	20.6

Maintenance Cost Savings

A sensitivity factor is applied to all the maintenance costs savings to measure the impact on the economic NPV with a range from -50% to 0%. If the overall maintenance cost savings, for some reason, is reduced by 10%, the project's economic NPV will decline by a 13% from the base case. The project is still viable, even from the economic point of view, if the maintenance cost savings decline by approximately 76%. Presumably this factor will only affect the Road Agency and not on other stakeholders. Table 17.18 shows the results of this test.

Table 17.18: Sensitivity Test of Maintenance Costs
(Millions of Rand in 2005 Prices)

Maintenance Costs	Economic NPV	Impacts on Stakeholders					
		RAL	Car	Tourist	Mini Bus	LGV/Agri	HGV
-50%	36.3	-208.4	48.8	2.3	176.9	4.6	12.1
-40%	50.1	-194.6	48.8	2.3	176.9	4.6	12.1
-30%	63.9	-180.8	48.8	2.3	176.9	4.6	12.1
-20%	77.7	-167.0	48.8	2.3	176.9	4.6	12.1
-10%	91.5	-153.3	48.8	2.3	176.9	4.6	12.1
0%	105.2	-139.5	48.8	2.3	176.9	4.6	12.1

VOC Savings

Table 17.19 reports on the tests of the impact on the economic NPV and stakeholders for changes in vehicle operating cost savings over a range from -50% to 0%. In a situation where the overall

VOC savings are 10% lower than the estimated value, the economic NPV will also decline by 20% from the result in the base case. The project is still economic viable up to a point where the overall value of VOC savings falls by approximately 50%.

Any reduction in VOC savings will lower the benefits received by all road users as presented in Table 17.19.

**Table 17.19: Sensitivity Test of VOC Savings
(Millions of Rand in 2005 Prices)**

VOC Savings	Economic NPV	Impacts on Stakeholders					
		RAL	Car	Tourist	Mini Bus	LGV/Agri	HGV
-50%	0.0	-139.5	25.7	1.2	103.0	2.6	7.0
-40%	21.0	-139.5	30.3	1.4	117.7	3.0	8.0
-30%	42.1	-139.5	34.9	1.7	132.5	3.4	9.0
-20%	63.1	-139.5	39.6	1.9	147.3	3.8	10.0
-10%	84.2	-139.5	44.2	2.1	162.1	4.2	11.1
0%	105.2	-139.5	48.8	2.3	176.9	4.6	12.1

Time Savings

A range from -50% to 0% for time saving was tested in Table 17.20. This results from a combination of changes in speed, wage rate of vehicle occupants, or the capital cost of cargo to transport goods. A 10% reduction in the overall value of time saving implies only a 3.3% drop in the value of the project's NPV. The project outcome is not very sensitive to this variable.

**Table 17.20: Sensitivity Test of Time Savings
(Millions of Rand in 2005 Prices)**

Time Savings	Economic NPV	Impacts on Stakeholders					
		RAL	Car	Tourist	Mini Bus	LGV/Agri	HGV
-50%	88.1	-139.5	47.5	2.3	162.3	4.3	11.2
-40%	91.6	-139.5	47.8	2.3	165.2	4.4	11.3
-30%	95.0	-139.5	48.0	2.3	168.2	4.4	11.5
-20%	98.4	-139.5	48.3	2.3	171.1	4.5	11.7
-10%	101.8	-139.5	48.5	2.3	174.0	4.5	11.9
0%	105.2	-139.5	48.8	2.3	176.9	4.6	12.1

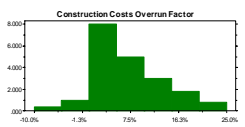
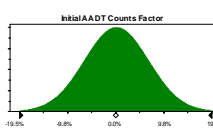
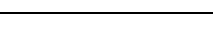
17.10.2 Risk Analysis

The above sensitivity analysis shows the variables that have a significant impact on the project outcomes. However, the sensitivity analysis only considers changes in one variable at a time and its impact on the project outcome. It does not account for uncertainties and fluctuations of key variables in the real world. In order to overcome this weakness, a risk analysis is carried out for a number of risk variables identified by the sensitivity analysis. The selected risk variables should have significant effects on project outcomes as well as being subject to uncertainty as expressed in their probability distributions.

Monte Carlo simulations provide one of the methods for risk analysis to approximate the dynamics and uncertainties of the real world. The risk analysis is performed in simulating the economic analysis many times using distributions for the values of the most sensitive and uncertain variables that affect the project. This process generates a probability distribution of project outcomes.

The risk variables selected for this project are: construction cost overrun, initial traffic AADT levels, traffic growth rate, and maintenance cost savings. The probability distributions of each of these risk variables and the possible range of its values are presented in Table 17.21.

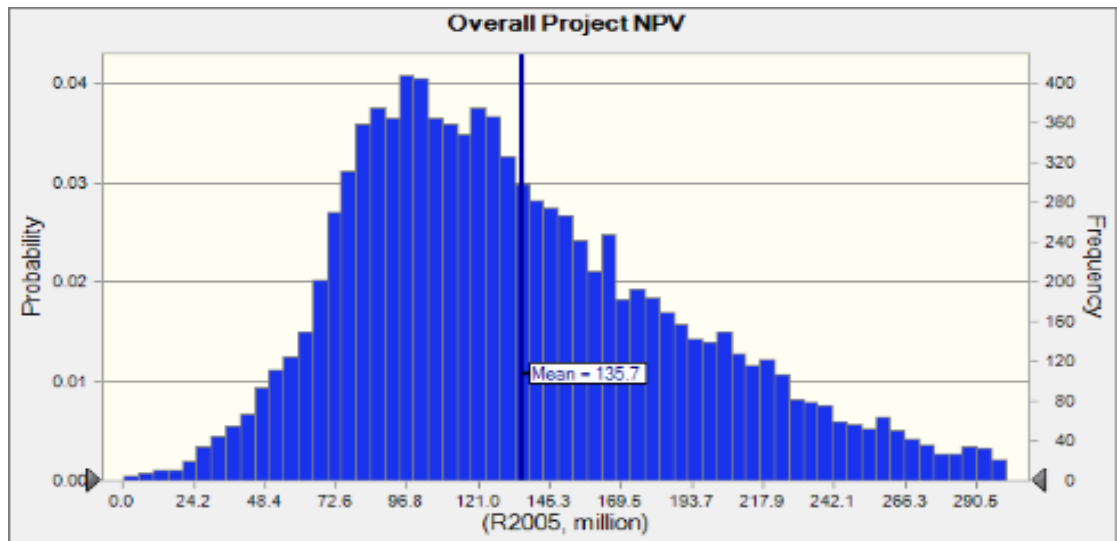
Table 17.21: Probability Distribution for Selected Risk Variables

Risk Variable	Probability Distribution Type	Range and Parameter		
		Min	Max	Likelihood
Construction Cost Overrun	Step Distribution			
		-10.0%	-5.0%	2%
		-5.0%	0.0%	5%
		0.0%	5.0%	40%
		5.0%	10.0%	25%
		10.0%	15.0%	15%
		15.0%	20.0%	9%
20.0%	25.0%	4%		
Initial AADT Counts	Normal Distribution			
		Mean		0.0%
Traffic Growth Rate	Triangular Distribution			
		Minimum		-1.0%

			Mode 0.0% Maximum 6.0%
Maintenance Costs Savings	Triangular Distribution		Minimum -10.0% Mode 0.0% Maximum 5.0%

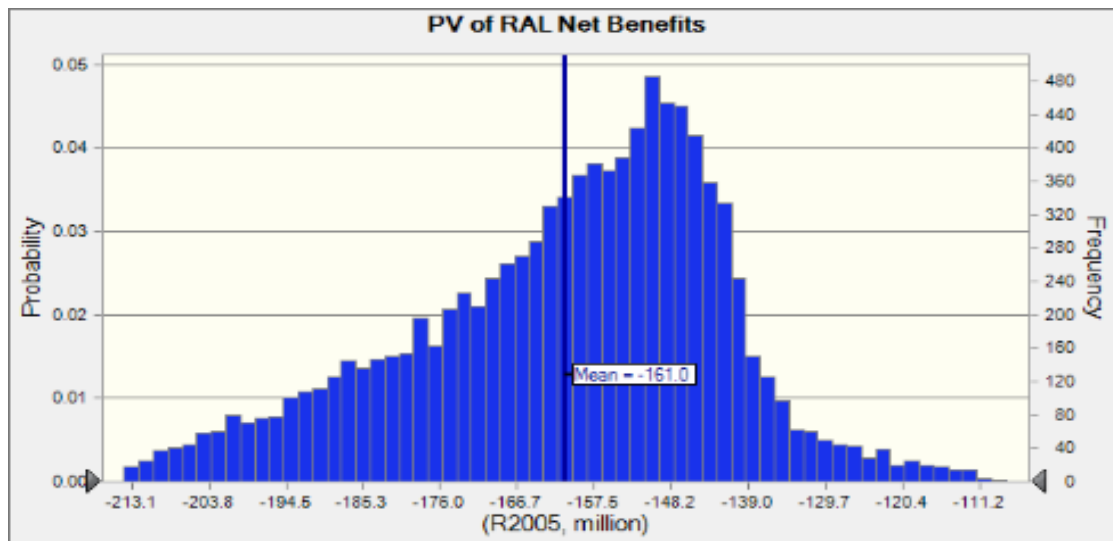
The results of the risk analysis were simulated for 10,000 runs. The simulation results shown in Figure 17.1 indicate that the expected value of the project’s economic NPV is R 135.7 million, which is higher than the deterministic value of R 105.2 million. Figure 17.1 presents the range of possible project outcomes that the economic NPV can take and the likelihood of the occurrence of these values. It ranges from the minimum gain of R 0.7 million to the maximum gain of R 359.5 million. There is zero probability that the economic NPV of the project may become negative under all possible circumstances defined earlier in the risk analysis.

Figure 17.1: Results of Risk Analysis on Economic NPV



The expected resource cost of this project to the Road Agency is about R 161.0 million. This is created by the heavy initial capital cost that is partially offset by savings in maintenance costs arising from the improvement of various road sections. Figure 17.2 shows that under any circumstances, the Agency will not have a positive PV of net benefits from this project, because savings in road maintenance costs are unlikely to outweigh the initial investment outlays.

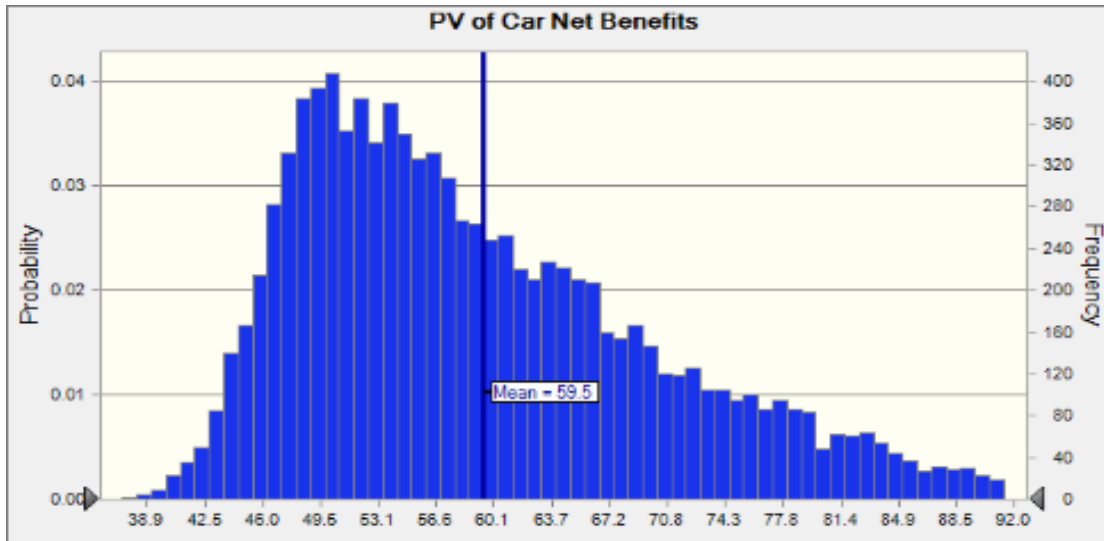
Figure 17.2: Results of Risk Analysis on Road Agency NPV



Each of the five classes of road users stands to gain from the improvement of this road. The expected values of their respective benefits accruing are all greater than the values in the deterministic case. At the same time, their respective probability of getting negative benefits is virtually non-existent. This simply means that all road users will surely gain as a result of this project. This is illustrated below for private car passengers and mini buses in Figure 17.3 and 17.4, respectively.

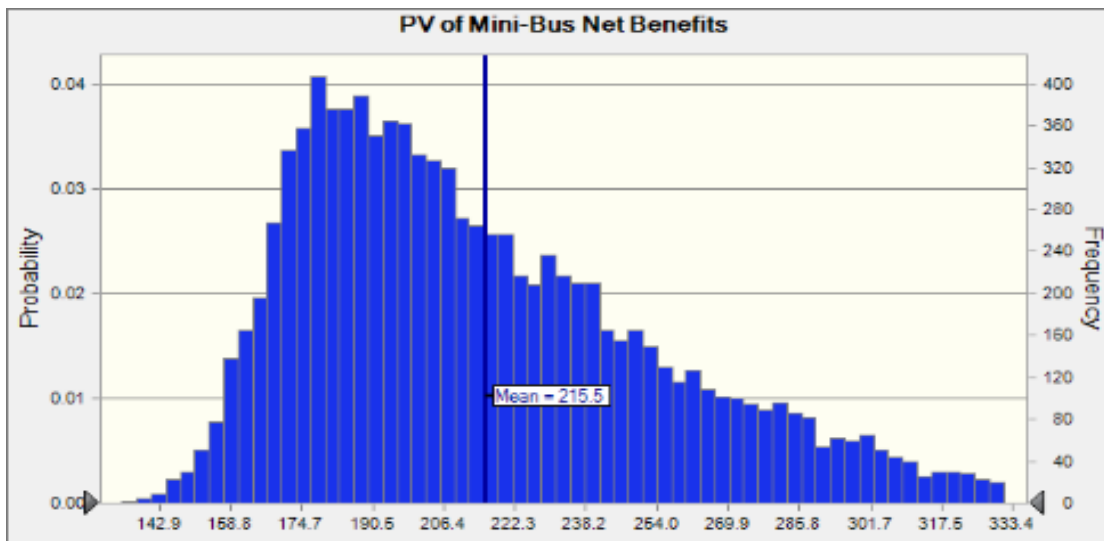
The risk analysis indicates that the expected benefits received by the private car passengers is R 59.5 million, which is larger than the deterministic case of R 48.8 million. Their net benefit is subject to significant variability, however, with a standard deviation of R 11.4 million. The gain ranges from the minimum R 37.4 million to the maximum R 106.0 million. There is zero probability of a negative NPV for this group.

Figure 17.3: Results of Risk Analysis for Car Passengers



By the same token, the mini bus users are expected to gain a mean value of R 215.5 million. This result mainly from the VOC savings and time savings of the existing (“without project”) road users. This gain is subject to a standard deviation at R 41.4 million. Nevertheless, the probability of getting a negative benefit for this group is nil, as shown in Figure 17.4.

Figure 17.4: Results of Risk Analysis for Mini Buses



It should be noted that the net benefit of upgrading Section D4050/D1583 is negative, with a mean value of R 39.2million, under all possible circumstances defined within the risk analysis presented earlier. There is zero probability a positive benefit resulting from improving this road section as of 2005. On the other hand, the other two sections, D4100 and D4250/D4190, have positive net benefits with the means of R57.1 million and R117.8 million, respectively, and zero probability of getting a negative benefit.

17.11 Concluding Remarks

Thischapter has followed the integrated investment appraisal methodology to evaluate the upgrading from gravel to tarred surface of several road segments in the Limpopo Province of South Africa. The project is to be carried out by the Road Agency of Limpopo, and no tolls are to be charged. The purpose of this study is to inquire whether the resources invested in each segment promise to be outweighed by its economic benefits.

Typically, benefits generated by road improvement include the reduction (perhaps increase) in resource costs on maintenance by the Road Agency, reduction in vehicle operating costs for road users due to improved road surface, time saving for road users due to an increase in average speed of vehicles, and possible reduction in the costs of accidents. This chapter has illustrated how to evaluate all but the last of these components.

For the Road Agency, this project suggests that savings in maintenance costs for R 137.8 million are not sufficient to cover the initial capital expenditures of R 277.2 million required by the improvement. However, the improvement of the road would generate a substantial benefit in terms of the savings of time and operating costs accruing to different classes of road users. As a result, the net economic benefit for the project is R 135.7 million.

The stakeholder analysis is also carried out for this project. The main beneficiaries of this investment will be the owners and users of mini-buses for R 215.5 million and of passenger cars for R 59.5 Million. Other road users, tourists, owners of light and heavy freight vehicles will also

share the benefits of the improved road by R 2.4 million, R 5.3 million, and R 14.0 million, respectively.

It is important to point out that the proposed road consists of three sections for which an individual economic assessment was carried out in this study. It appears that while the overall economic NPV of the project is expected to be approximately R 135.7 million, section D4050/D1583 has an expected negative NPV of R 39.2million when evaluated on its own. This section should therefore be excluded from the investment package, an act which would raise overall net benefits of the project to R 174.9 million.

Appendix 17A: Estimation of Vehicle Operating Costs

The vehicle operating cost (VOC) estimates are based on the road economic decision model (RED) developed by the World Bank and modified for South African realities by CSIR Transportek in 2003.¹⁸ The costs are essentially dependent upon terrain, roughness of the road, and type of vehicle. For each category, VOC is expressed as a function of roughness in the form of cubic polynomials, differing by category of road and type of vehicle. The general form is:

$$\text{VOC} = a_0 + a_1 * R + a_2 * R^2 + a_3 * R^3$$

Where R stands for the degree of road roughness, which is standardized and expressed in terms of the international roughness index. The results are shown in Table 17A.1. Costs are obviously expected to incur higher for traveling on a mountainous road than on a level road and on a rough road than on a smooth one.

¹⁸ Archondo-Callao, R., "Roads Economic Decision Model (RED) for Economic Evaluation of Low Volume Roads: Software Users Guide", Version 2.0, 3/15/01, The World Bank, Washington, D.C., USA. The model is customized for South African conditions by CSIR Transportek at the request of the Development Bank of Southern Africa (DBSA). Available at <<http://www.dbsa.org>>. The vehicle operating costs could be also computed using the functions calibrated by AFRICON Pietersburg for both light and heavy vehicles. "The Long Term Consequences of Various Budget Levels and Flood Damage Assessment on the Northern Province Road Network", Vol. 1, Prepared by AFRICON Pietersburg, Prepared for Roads Agency Limpopo, October 2000.

**Table 17A.1: Estimates of Average VOC by Terrain, Type of Vehicle, and Roughness
(Rand per Vehicle km in 2003 Prices)**

Terrain	Vehicle Type	Coefficients of the VOC Function				VOC (Rand per Vehicle km)		
		a ₀	a ₁	a ₂	a ₃	R at 2.0	R at 10.0	R at 20.0
Flat & Paved	Car	2.198	-0.028	0.017	-0.00031	2.204	3.261	5.790
	Utility	2.197	-0.016	0.017	-0.00031	2.229	3.388	6.048
	Light Bus	2.600	0.027	0.012	0.00010	2.702	4.164	8.722
	Medium Bus	3.047	0.027	0.012	0.00011	3.148	4.611	9.227
	Heavy Bus	3.788	0.026	0.013	0.00010	3.894	5.463	10.360
	Light Truck	2.954	0.162	0.012	-0.00022	3.324	5.554	9.218
	Medium Truck	3.397	0.181	0.013	-0.00023	3.809	6.251	10.259
	Heavy Truck	4.840	0.223	0.012	-0.00021	5.334	8.083	12.489
	Artic. Truck	6.856	0.287	0.023	-0.00047	7.518	11.552	18.021
Mountainous & Paved	Car	2.495	-0.028	0.015	-0.00027	2.497	3.458	5.843
	Utility	2.533	-0.015	0.015	-0.00027	2.562	3.631	6.145
	Light Bus	2.943	0.025	0.011	0.00014	3.036	4.391	8.811
	Medium Bus	3.583	0.038	0.009	0.00018	3.698	5.065	9.462
	Heavy Bus	4.534	0.045	0.010	0.00017	4.665	6.154	10.799
	Light Truck	3.669	0.161	0.010	-0.00016	4.028	6.092	9.512
	Medium Truck	4.260	0.200	0.009	-0.00015	4.696	7.042	10.774
	Heavy Truck	6.672	0.244	0.009	-0.00014	7.195	9.835	13.861
	Artic. Truck	8.961	0.242	0.018	-0.00029	9.515	12.886	18.637

Since the original model's output was expressed in prices of 2003 level, the final results were inflated into the prices for year 2005 by using an annual inflation rate of 6.5% for each of the years 2003 and 2004. Table 17A.2 presents the resulting VOC estimates in 2005 prices by type of vehicle, terrain and road roughness.

**Table 17A.2: Estimates of Average VOC by Terrain, Type of Vehicle, and Roughness
(Rand per Vehicle km in 2005 Prices)**

Terrain	Vehicle Type	VOC (Rand per Vehicle km)		
		R at 2.0	R at10.0	R at 20.0
Flat & Paved	Car	2.500	3.699	6.567
	Utility	2.528	3.843	6.860
	Light Bus	3.065	4.723	9.892
	Medium Bus	3.571	5.230	10.465
	Heavy Bus	4.416	6.196	11.751
	Light Truck	3.770	6.299	10.455
	Medium Truck	4.320	7.090	11.636
	Heavy Truck	6.050	9.168	14.166
	Artic. Truck	8.527	13.103	20.440
Mountainous & Paved	Car	2.720	3.837	6.598
	Utility	2.735	3.983	6.906
	Light Bus	3.267	4.837	9.913
	Medium Bus	3.786	5.366	10.496
	Heavy Bus	4.624	6.336	11.786
	Light Truck	3.997	6.425	10.487
	Medium Truck	4.505	7.210	11.670
	Heavy Truck	6.211	9.274	14.200
Artic. Truck	9.459	13.420	20.459	

Appendix 17B: Estimation of Average Vehicle Speeds

Estimates of the speeds are also based on the Roads Economic Decision Model (RED) developed by the World Bank and modified for South Africa. The average vehicle speed is a function of several factors, and the models were developed to estimate speeds for different types of vehicles under various terrain and road conditions.

For each category, the average vehicle speed (S), expressed in the number of kilometers per hour, is calculated below as a function of the degree of road roughness:

$$S = b_0 + b_1 * R + b_2 * R^2 + b_3 * R^3$$

The coefficients of the equations were estimated for each type of vehicle by terrain and the international road roughness and are shown in Table 17B.1. One would expect the vehicle speed is faster when road is smoother for the same type of vehicle. Similarly, given the same degree of road roughness, on average vehicles move faster in flat road as compared to the case in mountainous road.

Table 17B.1: Estimates of Average Vehicle Speeds by Terrain, Type of Vehicle, and Roughness (Km per Hour)

Terrain	Vehicle Type	Coefficients of the Speed Function				Speed (km per hour)		
		b ₀	b ₁	b ₂	b ₃	R at 2.0	R at 10.0	R at 20.0
Flat & Paved	Car	87.310930	0.169627	-0.275873	0.007344	86.61	68.76	39.11
	Utility	80.447861	-0.396431	-0.205073	0.005667	78.88	61.64	35.82
	Light Bus	84.601774	-0.941928	-0.210988	0.006361	81.92	60.44	32.25
	Medium Bus	74.745730	-0.124356	-0.220741	0.006043	73.66	57.47	32.31
	Heavy Bus	74.578226	-0.158145	-0.216589	0.005939	73.44	57.28	32.29
	Light Truck	79.405651	-1.691452	-0.131311	0.004518	75.53	53.88	29.20
	Medium Truck	74.316529	-1.822427	-0.104362	0.003841	70.28	49.50	26.85
	Heavy Truck	61.903260	-0.930893	-0.108541	0.003330	59.63	45.07	26.51
Artic. Truck	85.917625	-5.437581	0.099941	0.000352	75.45	41.89	19.96	
Mountainous & Paved	Car	67.707011	1.136416	-0.238360	0.005474	69.07	60.71	38.88
	Utility	60.813997	0.637159	-0.178888	0.004143	61.41	53.44	35.15
	Light Bus	63.274717	0.715527	-0.222646	0.005474	63.86	53.64	32.32
	Medium Bus	53.016936	0.683988	-0.160811	0.003647	53.77	47.42	31.55
	Heavy Bus	51.129871	0.615620	-0.145875	0.003264	51.80	45.96	31.21
	Light Truck	53.549798	0.218623	-0.144733	0.003569	53.44	44.83	28.58
	Medium Truck	49.905646	-0.038640	-0.117567	0.002995	49.38	40.76	26.07
	Heavy Truck	36.174877	0.023484	-0.062253	0.001431	35.98	31.62	23.19
Artic. Truck	45.592234	-0.206041	-0.120175	0.003325	44.73	34.84	20.00	

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 18:**

THE ABCs OF ELECTRICITY PROJECT ANALYSIS

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ABSTRACT

For the most part, the differences between the analysis of an owner-operated private venture project and that of typical public-sector projects are concentrated in the valuation of benefits. Most project costs are indeed cash outlays, just like those of a business venture, but this is not at all generally true on the benefits side. For example, public parks and highways (other than toll roads) rarely yield any cash inflows. The problem then is to find ways of estimating the true economic value of their benefits. In other cases (e.g., irrigation projects and toll roads), there is usually some charge for the use of the project's output, but that charge is typically a very poor measure of the project's true benefits. Again the challenge is to measure the true benefits of the project. Electricity projects appear to be in a different category, in that one hardly ever sees attempts to measure the actual benefits that users receive from such projects. Yet paradoxically, we still say we are quantifying the value of such benefits. This chapter conveys an understanding of the underlying economic principles that characterize the evaluation of investments towards the provision of electric energy.

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CHAPTER 18

THE ABCs OF ELECTRICITY PROJECT ANALYSIS

18.1 Background¹

For the most part, the differences between the analysis of an owner-operated private venture project and that of typical public-sector projects are concentrated in the valuation of benefits. Most project costs are indeed cash outlays, just like those of a business venture, but this is not at all generally true on the benefits side. For example, public parks and highways (other than toll roads) rarely yield any cash inflows. The problem then is to find ways of estimating the true economic value of their benefits. In other cases (e.g., irrigation projects and toll roads), there is usually some charge for the use of the project's output, but that charge is typically a very poor measure of the project's true benefits. Again the challenge is to measure the true benefits of the project.

Electricity projects appear to be in a different category, in that one hardly ever sees attempts to measure the actual benefits that users receive from such projects. Yet paradoxically, we still say we are quantifying the value of such benefits. The explanation of this apparent anomaly lies in what is called the "least alternative cost" principle. This principle states that one should not attribute to a project a value of benefits that is greater than the least alternative cost one would have to incur by providing an equivalent benefit stream in a different way.

This principle is fully general, but often seems quite redundant. Thus irrigation projects provide certain flows of water to a farming area, but with most of them one cannot even dream of a sensible alternative way to provide the same flows. In those cases the alternative cost (say of bringing the water in by truck) is so high as to be irrelevant in the analysis of a project to draw water from a nearby river, so one tries to put an economic

¹ This chapter is mainly taken from the Introduction to Cost-Benefit Analysis prepared for USAID by A.C. Harberger, "The ABCs of Electricity Project Analysis", (July 2010) and "More on the Cost-Benefit Analysis of Electricity Projects", (July 2010).

value on the river water itself, as it is used for irrigation. However, one does encounter irrigation projects in which pump irrigation (from underground aquifers) is a quite reasonable alternative to drawing water from the river. In these cases, it would be incorrect to attribute to the river-irrigation project a benefit stream that exceeded the alternative cost of getting the same water by way of pump irrigation.

While the least-cost principle can thus sometimes come into play for irrigation projects, one can say that it virtually always is the determining factor in estimating the benefits of electricity projects. The reason is that a next-best alternative of reasonable cost nearly always exists. Indeed, much of the time this next-best alternative is simply the standard way of doing things. The projects being analyzed in such cases then represent attempts to find new or different ways of doing things that are better than the standard alternative. The benefits of the “new or different” way are measured in such cases by the standard costs that would be saved, if the “new or different” project is in fact undertaken.

Now let us for the moment think of carrying out a cost-benefit analysis of this project without bringing the standard alternative into the picture in any way. Inevitably, this leads us to think of “this” project as somehow standing alone. At the moment when it is installed, it will presumably be the newest project in an existing system. But over time the older plants in this system will wear out, so the generating capacity of the system will decline year after year, as, one after the other, the older plants are abandoned. The overall generating capacity of the system would thus steadily decline over time. Even without a growing demand for energy, this would mean a market or economic price of electricity that would be steadily rising. In the more likely case of a continuously growing demand, this upward trend of price would be even more exaggerated. It would take a truly terrible project to fail a cost-benefit test, when its output was being valued at prices that were increasing exponentially throughout its economic life. One can almost say that cost-benefit analysis carried out under these assumptions would lose virtually all of its power to discriminate between good and bad projects. All would look good in the face of an ever-rising price of energy.

Now let us return to the real world. It obviously makes no sense to assume that our project -- call it plant E -- is going to be the last project to be built in our city's electricity network. We simply have to think of the system being operated in a sensible way. In the beginning plant E is added to an existing system consisting of plants A, B, C, and D. Over time plant A, the oldest, is likely to be the first to be retired. It will perhaps be "replaced" by plant F. But by that time the area's energy demand would likely have grown by enough to justify the addition of yet more capacity, say plant G. So, maybe 5 or 10 years down the line, the system would likely consist of plants B, C, D, E, F, and G. Further on, plants B and C will presumably also reach retirement age, and maybe plants H, I, J, and K will be added. The final step (in the analysis of "our" project -- plant E) will come when plant E itself reaches the point of being retired from the system. At that point the cost-benefit profile of project E would come to an end, perhaps with a blip of extra benefit representing the salvage value of the plant, perhaps with a blip of cost (e.g., for a nuclear plant) for the safe disposal of its remains.

The image we have tried to conjure up here is that of a motion picture representing the costs and benefits attributable to plant E, not standing alone, but imbedded in a system which is being managed intelligently, with other plants being retired when their staying in the system would entail more cost than benefits, and with new plants being added in a pattern that reflects the continuing use of cost-benefit principles. All of this lies behind the development of our basic tool of analysis, the "moving picture" of how the system would operate in the presence of our project, i.e., "with" the project E.

But this is not the end. In order to get the cost-benefit profile of project E, we have to make a forecast of how the system would operate in the absence of this project. In this scenario we do not do project E, but follow some alternative strategy in managing the electricity network. What strategy? There are only two good answers here: (a) the best alternative strategy, if we are able to identify such a strategy in specific terms, or (b) a "standard" alternative, defined by our best estimates of the typical costs of energy (varying by time of day, season of year, etc.) that we consider would emerge from a proper continuing application of sound cost-benefit analysis.

Answer (a) is likely to be feasible, if at all, only in sophisticated modern electricity systems, whose operations are governed by up-to-date computer systems designed to take into account all relevant factors in order to come up with a minimum-cost strategy for the system as a whole. More likely is answer (b) which is based on a more general knowledge of the costs of equipment, fuels and other material inputs, labor and other services, etc. This is the line that we will explore, using examples that move progressively from the simplest to the more complex.

18.2 The Simplest Case -- A Homogeneous Thermal Alternative

This section is meant to introduce readers to some very basic aspects of electricity economics. It should be thought of as dipping your toes in the water, not as a full-body immersion. In this exercise we will have one standard alternative -- a homogeneous thermal generator. By homogeneous we mean that the actual machines used in plants A, B, C, D, and E would all be physically the same (though of different ages), assuming all of them to be thermal plants (using fuel to generate energy). We will derive costs per kilowatt hour (kWh), based on the use of this standard generating equipment.

Assume we have data telling us that, given the current fuel price, the operating cost of this standard piece of equipment amounts to 4¢ per kWh. This mainly covers fuel, but it also takes into account the labor and other inputs involved in the actual operation of the equipment. It definitely does not include any return to invested capital. This will enter our picture at a later stage.

For now, let us simply concentrate on the idea that 4¢ per kWh is the appropriate cost of energy, measured at the plant, when that energy is being produced during off-peak hours. Why do we not add a charge for the use of the generating equipment itself? Simply because the simple addition of some extra kWh of output during off-peak hours does not require any more capital equipment than we already have.

When does the system require additional homogeneous thermal plants? Quite naturally, when demand threatens to push beyond the level of energy that our existing plants can deliver. We measure that capacity in kilowatts (KW), and also use the term “power” to refer to KW. Power in common parlance is something we can have without using it at all, and certainly without using it fully. But economists ask, when a system has more capacity (power) than it needs to satisfy demand, why charge for the use of that capacity? Nobody loses anything if idle capacity is put to use, while further excess capacity still exists. Thus, economists say, when idle capacity is present, the appropriate charge for energy would cover running costs (variable costs), not capital costs (fixed costs).

This line of thinking naturally leads to the idea of electricity charges that vary through time, being higher during peak-time hours and lower during off-peak hours. Charges linked to capital equipment (generating capacity) should appropriately be concentrated during peak-time hours, because if demand increases significantly during these hours, one will actually have to install additional capacity if that demand is to be met. And if one does not install new capacity in such a case, it will take an increase in the price of peak-time energy in order to constrain demand within the limits of the existing capacity.

An example will probably help to clarify how these concepts are actually used. Suppose that new capacity (of the homogeneous thermal variety) costs \$800 per KW, that the relevant discount rate (r) is 10%, and that the relevant depreciation rate (δ) for this equipment is 5% per year. Then, in order to justify the addition of a new KW of capacity, the necessary benefit is $(.15)*(\$800)$, or \$120 per year. If capacity is added that cannot generate such an annual benefit, the investment in that capacity is not justified. Keep in mind, then, that \$120 per year is the target revenue that should be expected, from new increments of capacity. How can one think of getting this revenue? From the sale of energy during peak-time hours. Thus, if the system’s peak is of 3000 hours per year, the needed peak time surcharge would be 4¢ per kWh. And if the peak were 2000 hours, the relevant peak-time surcharge would be 6¢ ($= \$120/2000$) per kWh.

Let us proceed on this latter assumption. Our “standard costs” for energy are 4¢ per kWh, off-peak, and 10¢ (= 4¢ for operating costs plus 6¢ of peak-time surcharge) during 2000 peak hours. Our next step is to apply this assumption to different types of hydroelectric projects. (Recall that we have only one type of thermal capacity, reflected in the modifier “homogeneous”). We will consider, in turn, run-of-the-stream hydro projects, daily reservoirs, and seasonal hydro storage projects.

18.3 Run-of-the-Stream Hydro Projects

The key characteristic of run-of-the-stream (ROS) projects is implicit in the title -- energy is generated using river water “as it flows”. Typically, a run-of-the-stream project will be situated on an incline, where water is flowing down a hill, or over a waterfall. Such projects typically channel the water through large tubes (penstocks) which carry it from the top to the bottom of the incline, and which lead directly into one or more turbines at the bottom of the hill. The running water turns the turbine, generating electric energy.

To evaluate the benefits of such a project one typically starts on the purely hypothetical assumption that the turbine capacity of the project will be fully used, through all the 8760 hours of the year. We then divide these hours into 2000 of peak-time and 6760 of off-peak use. Employing this information, we get, for each KW of turbine capacity:

2000 hours @ 10¢/kWh =	\$200.00
6760 hours @ 4¢/kWh =	<u>\$270.40</u>
Total	\$470.40 per KW

Now \$470.40 per KW per year is what the installed capacity would produce, if it were fully used all the time. This, of course, is not at all likely to be the case, as streamflow always varies quite significantly, mainly by season of the year, reflecting changes in rainfall and/or snowmelt. Thus, on average, the installed turbines will be used at only a fraction of their full capacity. Simply for our example, we will assume this fraction to be 60%. Hence, estimated benefits = $.6 \times \$470.40 = \282.24 .

We introduce these benefits into our profile of the run-of-the-stream project, deducting capital costs during the construction phase of the project and maintenance plus (very minor) operating costs during its operating phase. The result is a project profile which we then can evaluate, using, of course, the same discount rate (here 10%) that we employed in the derivation of the 6¢ peak-time surcharge.

Readers may have noticed that in the above exercise, the analysis was carried out “per kilowatt (KW)” of installed capacity, and complemented by an assumption of the fraction (in this case 60%) of that capacity which was expected to be utilized in the course of a typical year. But as one focuses on this feature, one quickly comes to wonder, why 60 and not 40 or 80 percent? It is to this question that we now turn.

First, let us recognize that in any real-world case, the answer will depend on the hydrological characteristics of the stream (and site) in question. There may be rivers whose streamflow is so steady that there is only a 20 or 30 percent difference between the lowest and the highest daily flow during the year. In such a case there is not much range for choice as to how many KW of turbine capacity to install. But such cases would be hard to find in the real world. Most rivers and streams are subject to very heavy streamflow in the rainy season (or the period of biggest snowmelt). Some even dry up completely in the driest period of the year, and for most the lowest streamflow is only a modest fraction of the highest one.

Thus the designers of a typical run-of-the-stream project are faced with a serious problem of choice. If they build the project so as to make use of nearly all the streamflow of the year, they will have to install enough turbine capacity to process the huge rainy-season flows. But then, during the rest (which is most) of the year, the much lower streamflow will leave most of the installed turbines idle for many months running. On the other hand, if the designers decide to keep the fraction of capacity use high, they will have to install turbine capacity geared principally to the rate of streamflow in the drier part of the year. They will then end up using their turbines most of the time, but they will be allowing a lot of the stream’s annual water flow to go to waste. The dilemma is -- build big, and a lot

of that turbine capacity will be idle a lot of the time; build small, and your problem will not be one of idle turbine capacity but rather one of a lot of water passing by unused (for electricity generation), simply because you don't have the turbines to process it.

This dilemma represents an economic problem -- one of weighing benefits against costs. This problem is best tackled at the design stage so as to ensure that whatever choice is made as to how much turbine capacity to install, that capacity is achieved at the lowest economic cost. The key facts needed for solving this problem are: (a) a graph of the expected (likely) streamflow, period by period (perhaps day by day) throughout the year. This graph will most likely have a single peak sometime in the wettest season and a single trough (sometime in the driest period). The benefits of adding turbine capacity get smaller and smaller, as we contemplate adding successive increments of capacity. The first few KW of capacity will promise 100% usage, as long as they involve using less than the lowest expected streamflow. On the other hand, the last few KW of capacity that we might add, would promise usage only in the few days of absolutely highest streamflows. Very likely, then, benefits will amply exceed cost for the first few KW, while cost will almost certainly exceed benefits for additions to capacity that can expect to be utilized only a few days per year. Somewhere between these extremes, then, we should be able to find an optimum level for turbine capacity -- a point up to which benefits exceed costs for each successive increment to design capacity, and beyond which costs exceed benefits for each successive increment. This is the sort of calculation that should be carried out in the process of designing any run-of-the-stream project. Obviously, it involves repeated applications of the procedure outlined in the first part of this section, with the ultimate choice being for that turbine capacity which yields the greatest expected net present value (i.e., the greatest expected excess of the present value of benefits over the present value of costs).

18.4 Daily Reservoir Hydro Projects

The daily reservoir (DR) can be thought of as a sort of add-on to a run-of-the-stream project, either at the design stage, or later. Here we will assume that we are dealing with a

run-of-the-stream project that is already operating. Moreover, we will assume that this existing project is well-designed for its purpose, following the principles presented above.

In our example of a run-of-the-stream project, the installation was expected to produce peak-time energy during 2000 hours, and off-peak energy during the remaining 6760 hours of the year. This means that over the course of the year, around 23% ($= 2000/8760$) of the water flow would be used to produce electricity that was worth 10¢ per kWh, while the remaining 77% ($= 6760/8760$) would be used to produce energy worth only 4¢ per kWh.

A daily reservoir project has two principal objectives: (a) to convert to peak-time production much of the water that would normally go to produce off-peak energy in a run-of-the-stream operation, and (b) to utilize some of the water that would otherwise go to waste (again in a run-of-the-stream case). To accomplish objective (a), a small dam is built upstream of the ROS project. It accumulates water during the off-peak hours, and then releases that water during peak-time. In this way it produces 10¢/kWh energy with the same water that would otherwise end up generating energy worth only 4¢/kWh. The substantial net gain of 6¢/kWh is the principal benefit of the daily reservoir project.

This benefit comes with a significant cost, however. First and foremost, there is the cost of the dam itself, and possibly of a regulating dam downstream of the project, designed to deliver a steady streamflow to downstream users. If the amount of turbine capacity in the project is not increased, the benefit of extra peak-time energy would be limited to the amount by which the turbine capacity of the ROS project exceeded the streamflow-determined ROS output of each day. Thus a project with 5 MW ($= 5000$ KW) of turbine capacity might in one part of the year be processing a streamflow that generated 2000 kWh during each hour of peak. This could be brought up to 5000 kWh per peak-time hour, but not further, if one left turbine capacity unchanged. All this benefit would be of type (a). Obviously, in periods of the year where the streamflow itself was enough to generate 5000 kWh/hr, the installed capacity would be fully utilized by the ROS project,

and the addition of the daily reservoir would have no effect of shifting water (and therefore energy output) from off-peak to peak hours.

Thus, assume:

T_o = initial turbine capacity, in KW

S_i = expected streamflow per hour of day i expressed as the number of KW which that streamflow can generate.

H_{p_i} = number of peak-time hours on day i

H_{n_i} = number of off-peak hours in day i ($= 24 - H_{p_i}$).

Then we have $H_{p_i}(T_o - S_i)$ = the maximum number of kWh that can be converted from off-peak to peak, if T_o remains unchanged. This is a maximum, because in periods of very low streamflow, one may not reach an output of $H_{p_i}T$ in peak-time, owing to low streamflow throughout the day.

The amount of water available to be shifted from off-peak to peak is simply $H_{n_i}S_i$, the total water flow in off-peak hours. All this would represent off-peak energy actually produced by the pre-existing ROS project, if $T_o > S_i$. In case $S_i > T_o$, the difference $(S_i - T_o)H_{n_i}$ would represent water that passed by without producing any electricity in the original ROS project. So if the increase in generating capacity ΔT is such that $H_{p_i}(T_o + \Delta T) > 24S_i$, that means that, with a capacity increase of ΔT , the full streamflow of the day ($= 24S_i$) can be processed during peak-time hours. This would include a shift of all the water that had previously gone to produce off-peak energy, plus all the water that had “gone to waste” because of limited turbine capacity. The benefit for day i of the DR project would then be the excess of this value over the value of the energy that the original ROS project would have produced.

On days when $(T_o + \Delta T)H_{p_i}$ is smaller than $24S_i$, the augmented project will not utilize the full streamflow of the day at peak-time, but may well use it during peak plus off-peak

hours. In this case the gross benefit for day i of the DR project would then be measured by $H_p(T_o+\Delta T)$ times the peak-time price of energy, plus $[24S_i - H_p(T_o + \Delta T)]$ times the off-peak price of energy. The term in square brackets represents the water that is available ($= 24S_i$) minus that amount which is used to generate peak-time energy [$=H_p(T_o+\Delta T)$]. From this, as before, we would have to subtract the value of the energy that the original ROS project would have produced.

Just as, for the ROS project, a separate optimization had to be made to determine the optimal level of T , so here a similar process should be used to determine the best level for ΔT , the increment of turbine capacity.

Special note should be taken of the fact that no considerations of electricity demand entered into the above analysis, either of ROS or of daily reservoir projects. The reason for this is the way in which such projects fit into the operations of most electricity systems. As we will see in greater detail later, the principle governing the management of electricity systems is that when demand is low, one uses only those sources of energy that have the lowest running cost per kWh. Then, as energy demand increases, additional capacity is turned on, starting first with the second cheapest per kWh, then turning on the third cheapest, and so on up the scale. Only at times of very high (peak) demand does the system resort to its generators with the highest running cost.

The mere contemplation of how an ROS system operates tells us that it has practically zero running costs. All that is needed is for somebody to make sure that the water that is flowing in a given hour is actually channeled through the turbines to generate energy. Because ROS energy is so cheap, it is always, in principle, the first source to be used in cases of low demand. And it is used every hour of the day, all through the year, being interrupted only for maintenance and repair. Since ROS capacity constitutes only a small fraction of the total capacity of a typical electricity system, it is in fact used all the time and is practically never used only partially for lack of demand for its energy output.

In the case of daily reservoirs, once again their running cost is next to zero, but since the great bulk of their output is at peak-time, they are then working along with all or nearly all of the other sources of energy in the system and of these they (along with ROS installations) have the lowest running cost. Any variation in peak demand will thus be absorbed by other, higher-cost contributors to the supply of peak-time energy. This explains why demand considerations did not enter into the preceding analysis of daily reservoir projects.

18.5 Seasonal Hydro Dams

While daily reservoirs have the effect of letting managers decide when, within a given day or so, water will be needed to generate energy, seasonal hydro dams aim at allowing such water use to be shifted from one part of the year to another. The typical case for which a seasonal dam will be contemplated is one where there is one season in which the energy from a given stream would have a high value, and another in which that value would be much lower. Some cases thus could arise because streamflow is very heavy in one part of the year and very light in another, while energy demand is pretty steady over the year. Other cases could arise in which the streamflow is pretty steady but demand is highly concentrated, perhaps in winter for lighting and heating, perhaps in summer for air conditioning.

As in the preceding sections, we will analyze seasonal hydro dams as part of a system in which the “standard” way of generating electricity is via homogeneous thermal capacity. Again, this standard capacity will be assumed to have a running cost of 4¢ per kWh, and a capital cost of \$800 per KW, with a depreciation rate of 5% per annum. The relevant discount rate for cost-benefit analysis will, as before, be 10%.

The first question to be answered is whether the energy used in a seasonal storage project should be considered as “baseload” or “peaking” capacity. We have already seen how run-of-the-stream capacity is quite naturally “baseload”, while the whole reason for building daily reservoir capacity is to augment the system’s supply of peak-time energy.

In our simplified case of homogeneous thermal capacity, we would have what is called a “stacking pattern” in which ROS capacity sits at the base, homogeneous thermal capacity occupies the middle, and daily reservoir capacity occupies the top. This means that when demand is very low, only ROS capacity will be used. When demand exceeds ROS capacity, that capacity will first be fully used, and it will be supplemented as needed by the output of our homogeneous thermal plants. Only in the hours of greatest demand during the day, will the water accumulated in daily reservoirs be used to “top off” the energy supply coming from run-of-the-stream and homogeneous thermal sources.

Now we come to the question at hand -- what place in this stacking pattern should be occupied by seasonal hydro capacity? Since we already know that ROS capacity belongs in the base, and that daily reservoir capacity should be used for peaking, we can concentrate on the question of which, as between homogeneous thermal and seasonal hydro capacity, should be turned on first. In particular, should seasonal hydro be thought of as part of the base, or as an appropriate way to serve peak-time demand?

The best way to focus on this question is to assume that we have one or more seasonal hydro dams already built. They will accumulate water in the wet season, and deliver energy in the dry season.² To make our analysis quite clear and straightforward, we must bear in mind that the storage capacity of our seasonal dams will not change, depending on our decision of how to use them. The amount of water they can store was determined when they were built. However, the amount of energy they can generate in any given hour typically is subject to change, because such dams are designed to leave room for adding turbines (up to some limit). In a simplified system consisting of seasonal hydro plus homogeneous thermal capacity, we would have a given level of peak demand, say 1000 MW. If our seasonal hydro capacity is used as baseload, its stored water will be spread over 24 hours a day, for, say, 9 months of the year. To use the water in this fashion perhaps only 200 MW of turbine capacity will be needed (because this capacity will be running virtually continuously.) If on the other hand, the seasonal dams are used

²Alternatively, we can think of them as accumulating water in the season of low electricity demand (say winter) and delivering it in the season of high electricity demand (say summer).

for peaking, they may be occupied for many fewer days, and for varying numbers of hours on these days. The amount of turbine capacity needed in this case will be much larger, say 600 MW. So we have case A, where seasonal hydro is used for baseload, in which we would have turbine capacity of 200 MW by hydro, supplemented by 800 MW of homogeneous thermal. Alternatively, for case B, we would have to install 400 MW of homogeneous thermal capacity, plus, as indicated, 600 MW of turbine capacity in our hydro dams. As we move from case A to case B, then, we are subtracting 400 MW of homogeneous thermal capacity, and adding 400 MW of turbine capacity in our seasonal hydro dams. Here the cost-benefit analysis is a no-brainer. First, it is much cheaper to add 1 MW of turbine capacity to an existing dam with a place already prepared for additional turbines, than to add 1 MW of homogeneous thermal capacity, which entails building the whole plant plus its associated turbines. And second, using homogeneous thermal capacity for peaking will involve start-up and shut-down costs, which are practically zero in hydro dams, where turbines can be turned on or off simply by pressing a button or flicking a switch.

How seasonal hydro capacity will be used during the wet season depends mainly on physical conditions such as streamflow and the storage capacity of the hydro dams. Start with the idea of using these dams for peaking all year round -- including the wet season. This would mean that excess streamflow -- over and above that needed to satisfy peak demand, would be stored for later use. But suppose this would lead to the dams being filled before the wet season ends. In such a case it is much better to use the excess water in off-peak hours, rather than allow it to go to waste. This could mean that some thermal plants would be shut down for part or all of the wet season, their place being taken by turbine capacity in the hydro dams.

There is one additional point to be made with respect to the seasonal hydro versus thermal tradeoff. In our numerical example, we had 600 MW of seasonal hydro turbine capacity plus 400 MW of thermal capacity as our preferred solution. Under these circumstances it is clear that for most of the hours of the year when hydro capacity is being used, the system's thermal plants will be operating at full capacity. The resulting

number of hours of full-capacity thermal operations can be called the “thermal peak”. This can easily be a lot larger than the “system peak” or “demand peak” which we earlier assumed to be 2000 hours per year.

Now let us backtrack and ask, what is the logic behind our earlier derivation of a 6¢ per kWh peak-time surcharge, to be applied over a system peak of 2000 hours per year. That logic was that it was the growth of demand at peak-time that called forth the need for more (homogeneous) thermal capacity -- hence the scarcity value of peak-time energy should cover not only the running cost but also the capital cost of thermal capacity. We got the 6¢ per kWh peak-time surcharge by first calculating the annualized capital cost of thermal capacity of \$120/KW ($= .15 \times \$800/\text{KW}$). We then divided this \$120 by the 2000 hours of system peak. That calculation no longer makes sense in the presence of significant amounts of seasonal hydro capacity. Now the thermal peak is going to be significantly longer -- say 4000 hours per year, because our seasonal dams have enough capacity to deal with more than just the system peak. Hence if demand grows (at peak as well as off-peak hours), what is going to happen is that our given hydro storage capacity will still fill the system peak and more, but the increase of demand will leave a gap which will (under our assumptions) be filled by adding to the number of homogeneous thermal generators in the system. Thus incremental thermal capacity will operate (again under our assumption of homogeneity) for the 4000 hours of thermal peak, not just the 2000 hours of the system or demand peak. Hence the peak that we should use for the calculation of the peak-time surcharge is 4000 rather than 2000 hours, and the resulting surcharge becomes 3¢ rather than 6¢ per kWh. The total collected to cover capital cost is exactly the same \$120.00 per KW per year as before, only now it is spread over 4000 rather than 2000 hours. Why? Because this is the number of hours that newly-added homogeneous thermal plants are expected to operate.

Up to this point we have carried the discussion on the assumption that the price of off-peak energy was equal to its running cost (here 4¢/kWh), and that of peak-time energy was equal to running cost plus a peak-time surcharge of either 6¢ (without seasonal hydro) or 3¢ (with seasonal hydro) per kWh. These assumptions make economic sense,

and can be said to carry out, in our simple example, the lessons of modern electricity economics, a branch of economic analysis set in motion by French technocrats working at or with Electricité de France in the early 1950s. It was their great insight that the true economic marginal cost of electricity would naturally vary by hour of the day, day of the week and in many cases season of the year, and it was their recommendation that these variations should be reflected in the prices paid by the users of electric energy. The French started the time-pricing of electricity in the 1950s. They were followed by many (perhaps by now even most) other countries in adopting this innovation. Typically, time-pricing is first applied to large industrial and commercial users, and only gradually and often only partially extended to domestic customers. But by now time-pricing of energy for household use is also pretty widespread.

But what do we do in cases where time-pricing is not used, and where the pricing system therefore does not reflect true economic cost? The answer here is very simple. The fact that the prices paid by users do not reflect the true economic cost of energy does not change that true cost. Even if peak-time energy is given away for free to some users, that does not alter the fact that it costs 10¢/kWh (without seasonal hydro) or 7¢/kWh (with seasonal hydro) in our examples.

And since our measure of the benefit of hydro projects (whether they are run-of-the-stream or daily reservoir, or seasonal storage) is based on the amount of thermal generating costs that they end up saving, all the calculations that we have done assuming “prices” equal to 4¢, 10¢, and 7¢ remain valid. But now they should be recognized as measures of system marginal costs of electricity under the relevant assumed conditions. It is by adding up the savings of these costs that a new project accomplishes, that we obtain a measure of the project’s direct benefits.

18.6 Heterogeneous Thermal Capacity -- A Vintage Approach

The assumption of homogeneous thermal capacity, which was carried through to this point, has made it easy to describe what we called the “standard alternative” to each of

the types of hydro projects that were analyzed there. This assumption is abandoned now, in favor of a more realistic assumption of heterogeneous thermal capacity. But even here there are two distinct ways of introducing heterogeneity -- one which considers changes taking place over time in the characteristics of the thermal plants that are being added to the system, and the other which looks at different design characteristics of thermal plants that have different functional roles within the system.

In this section we will be concerned with the first kind of heterogeneity. Our thermal system is here assumed to comprise plants dating from different prior years -- the oldest are assumed to be the least “thermally efficient” and therefore to have the highest running cost per kWh. The newer is the plant, the more efficient it is assumed to be, hence the lower will be its running cost per kWh. These assumptions lead to a “stacking pattern” in which the newest thermal plant will be the first one to be turned on (after run-of-the stream capacity is fully used). This will be followed by the second newest, then the third, then the fourth newest thermal plant, in ascending order of running cost as older and older plants are turned on. There is nothing that is difficult to understand up to this point. It is simply an application of the idea that whatever is the level of demand, we try to use that mix of generating equipment which satisfies that demand at the lowest running cost.

But now we have to modify previous scenario. There, when we added a new plant, its natural function was to fill a “thermal peak” of demand that would otherwise go unmet. Since the equipment being added was fully homogeneous with the already existing thermal plants, it was right to consider this added plant as the last one to be turned on. Now, however, we are assuming that the newest plant is more efficient than the older ones, hence if we install it, it should be not the last but the first thermal plant to be turned on.

This shift of function gives rise to a new possibility, namely that it may be worthwhile to add a new thermal plant (say plant E) to an existing structure consisting initially of plants A, B, C, and D -- even if the system demand for energy remains the same (i.e., is not

growing through time). The motive for this addition would in such a case be exclusively the saving of running cost. The “new” system would not produce more energy than the “old” one -- the number of kilowatt hours would not change, but the saving in running cost might be sufficient to justify the construction of plant E.

Table 18.1 gives an illustration of how a new plant (here plant E) might turn out to be justified even if the system demand for energy is not increasing. The table is concerned only with the thermal part of the system. There may be run-of-the stream capacity serving as baseload, and daily reservoir or seasonal storage capacity serving at peak times, but their contributions are quite naturally assumed to remain the same, since system demand is not changing.

The “old” system (Panel 1) of Table 18.1 is what would occur if plant E is not built at this time, while the “new” system (Panel 2) represents what would occur if plant E is in fact constructed. The figures refer to the first year that plant E would operate if that investment is made.

Panel 1 shows the stacking pattern that would prevail if plant E is not built. Each plant is assumed to have a capacity of 50 MW, so in Panel 1, plant D (the newest) is assumed to be operating for 6000 hours, plant C for 4800, plant B for 3600, and plant A for 2400 hours. Multiply these by 50 MW in order to get the megawatt hours shown in the first column of Panel 1. The assumed running costs per kilowatt hour are shown in Column 2, and the total running costs for each plant appear in Column 3 (recall that one megawatt hour equals 1000 kWh).

Panel 2 shows what would happen if project E were undertaken, in the absence of any increase in system demand. Since all the plants are assumed to have a 50 MW capacity, and since system demand is unchanged, the net effect of adding plant E is that plant A will be retired (or relegated to a standby role). Plant E now becomes the first thermal plant to be turned on, and plant B becomes the last. As a result, system running costs end up lower than in Panel 1, the total saving being \$4.8 million over the year. If the capital

cost of building plant E is \$600/KW, for a total of \$30 million for a 50 MW plant, the project would appear to be worthwhile using the criteria applied in Part I (a 10% discount rate plus a 5% rate of depreciation for the plant). The required yearly return on capital for plant E would then be \$4.5 million, while the estimated actual return is \$4.8 million.

It is worth taking time to note the composition of this \$4.8 million benefit. Simply looking at the two panels of Table 18.1, one sees that in Panel 2, plant E occupies the role that plant D played in Panel 1, plant D does what C did in Panel 1, plant C occupies the role previously played by B, and plant B does what A previously did. This is a perfectly accurate description of the difference between the two panels, but thinking of the new plant E as taking the place formerly occupied by plant D is not a helpful way of describing the change. To maximize insight, we have to focus on the fact that it is plant E that is being introduced into the system. We then have to ask, as E generates its 300,000 megawatt hours, what sources are it in effect replacing. The answer can be found by asking what change takes place in the output of each of the other plants, as we move from Panel 1 to Panel 2. The answer is that D, C, and B, each “lose” 60,000 megawatt hours of output, while A loses all of its 120,000 megawatts. These “losses” add up precisely to the 300,000 megawatt hours generated by plant E in Panel 2.

But this is only the beginning. When E supplants D for 60,000 megawatt hours, the saving of running cost is 1/2¢ per kWh or \$5 per megawatt hour. When E supplants C, the saving is \$10 per mwh, when it substitutes for B, \$15 per mwh is saved. And finally, vis-a-vis A, the saving is 2 1/2¢ per kWh, or \$25 per megawatt hour. Now, as if by magic, if we take $(\$5 \times 60,000)$ plus $(\$10 \times 60,000)$ plus $(\$15 \times 60,000)$ + $(\$25 \times 120,000)$, the result is \$300,000 + \$600,000 + \$900,000 + \$3,000,000, equal precisely (and necessarily) to the \$4.8 million of saving in total cost, which we calculated directly in Table 18.1. Thus the cost saving for any year t can be represented by $\sum_j H_{jt}(C_j - C_n)$,

where C_n is the running cost per kWh of the new plant, C_j is the running cost per kWh of old plant j, and H_{jt} is the number of kWh for which plant j is being displaced by the new plant, during year t.

Table 18.1
Justifying a New Thermal Plant
Even when System Demand is Constant

PANEL 1 -- "OLD" SYSTEM

	<u>Megawatt Hours</u>	<u>Running Cost</u> <u>Per kWh</u>	<u>Total Running</u> <u>Cost Per Plant</u>
Plant D	300,000	3¢	\$ 9 million
Plant C	240,000	3 1/2¢	\$ 8.4 million
Plant B	180,000	4¢	\$ 7.2 million
Plant A	120,000	5¢	\$ 6 million
Total running cost of thermal plants			\$30.6 million

PANEL 2 -- "NEW" SYSTEM

	<u>Megawatt Hours</u>	<u>Running Cost</u> <u>Per kWh</u>	<u>Total Running</u> <u>Cost Per Plant</u>
Plant E	300,000	2 1/2¢	\$ 7.5 million
Plant D	240,000	3¢	\$ 7.2 million
Plant C	180,000	3 1/2¢	\$ 6.3 million
Plant B	120,000	4¢	\$ 4.8 million
Total running cost of thermal plants			\$25.8 million

Saving of running cost = \$ 4.8 million/year

Capital cost of Plant E @ \$600/KW × 50 MW = \$30 million

The above analysis works without modification for all cases in which total demand remains the same “with” the new plant as “without” it. However, that is a rather special case. We get a clue as to what the general case looks like when we recall that in our earlier example (Section 18.2), the output of the new plant went 100% to producing energy at the thermal peak, and that the peak-time surcharge was actually calculated by asking what that surcharge would have to be in order for investment in a new plant (aimed at covering the increase in demand in the hours of thermal peak) to be justified.

What we are going to do now in Table 18.2 and Table 18.3 is to create a situation in which investing in plant E is not justified if system demand is not increasing, but can be justified if there is a sufficient rate of increase in system demand. Table 18.2 should be self-explanatory as it simply repeats the calculation of Table 18.1, but with lower output for each plant. Now, in Panel 1, plant D produces 200,000 kWh rather than 300,000. Similarly each of the other plants has only 2/3 the output it had in Table 18.1. This simply would reflect different demand characteristics in the system. Here D would be operating for 4000 rather than 6000 hours per year, and A would be operating for 1600 rather than 2400. In such a system, our cost-benefit analysis would tell us to say no to plant E, if system demand were constant through time. However, suppose demand were growing. If we say no to plant E, we must do something to contain demand so that it stays within the combined capacity of plants A, B, C, and D. How to do this? Via a peak-time surcharge, of course.

For simplicity, let us assume that the thermal peak is equal to the 1600 hours that plant A was running in Panel 1 of Table 18.2. Then we would derive the peak-time surcharge by asking what peak-time surcharge it would take, in order for the “next” addition to capacity to be justified. Using our discount rate of 10% and our depreciation rate of 5% we would have a “required” return of \$4.5 million on the investment (\$30 million) in plant E. We would have cost savings of 1/2¢, 1¢, and 1 1/2¢ with respect to plants D, C, and B, and these would apply to 40,000 mwh each. The dollar amounts saved would be \$200,000, \$400,000 and \$600,000 respectively, adding up to \$1.2 million. Thus plant E’s energy at peak-time (1600 hours) would have to generate (\$4.5-\$1.2) million of return to

capital if the investment in E is to be worthwhile. This would be created over 1600 hours \times 50,000 KW of capacity, or 80 million kWh. The peak-time surcharge (over and above plant B's running cost) would then have to be $\$3.3 \text{ million} \div 80 \text{ million kWh} = 4.125\text{¢}$ per kWh. The peak-time price would be 8.125¢ per kWh.

The calculation would be different if the system peak were equal to, say, 1000 hours (rather than 1600). Assuming A's turbines to be used at full capacity during this 1000 hour peak, they would produce 50,000 megawatt hours during this period. Plant E would not be substituting for plant A during this time, but it would do so (if E is built) for the remaining 30,000 mwh of A's output (as shown in Panel 1). Thus H_{at} would be 30 million kWh while H_{bt} , H_{ct} and H_{dt} would each be 40 million kWh. These substitutions would account for a combined saving in running cost of $\$1.95 \text{ million}$ ($= \$200,000 + \$400,000 + \$600,000$ for plants D, C, and B, as before, plus $\$750,000$ for plant A, covering the 30,000 mwh that we have calculated for H_{at}). In order to generate the $\$4.5$ million of benefits that are required to justify investing in plant E, the peak-time surcharge (over A's running cost of 5¢) would have to generate benefits of $\$2.55 \text{ million}$ ($= \$4.5 \text{ million} \text{ minus } \1.95 million). Per kWh, this "surcharge" would be 5.1¢ per kWh. The peak-time price of energy in this case would be $\$10.1\text{¢/kWh}$.³

³In this calculation we assume that the timing of plant E's introduction into the system would be such that even in E's presence both A and E would be fully utilized during the 1000 hours of system peak. This gives rise to the question, how is the system managed during the interval in which system peak demand exceeds 200 MW (the sum of the capacities of A, B, C, and D) but falls short of 250 MW (where all five plants would be operating at capacity). The economist's answer to this question is that the peak-time price of energy would move up gradually from 3¢ ($=$ A's running cost) to 8.4¢ (the level that would justify introducing plant E). The object of such a gradually increasing peak-time price would be to contain peak demand within the 200 MW limit, until the point where the introduction of plant E is optimal. This answer, however, involves too much fine-tuning for the practical world. The practical solution is simply to set the peak-time price at 7.9¢ soon as system peak demand threatens to exceed 200 MW at a price of 3¢ , and then introduce plant E at the point where it can fully substitute for plant A.

Table 18.2
Showing a Case where Investing in a New Plant
Is not Justifies while System Demand Remains Constant

PANEL 1 -- "OLD" SYSTEM

	<u>Megawatt Hours</u>	Running Cost <u>Per kWh</u>	Total Running <u>Cost Per Plant</u>
Plant D	200,000	3¢	\$ 6 million
Plant C	160,000	3 1/2¢	\$ 5.6 million
Plant B	120,000	4¢	\$ 4.8 million
Plant A	80,000	5¢	\$ 4 million
Total running cost of thermal plants			\$ 20.4 million

PANEL 2 -- "NEW" SYSTEM

	<u>Megawatt Hours</u>	Running Cost <u>Per kWh</u>	Total Running <u>Cost Per Plant</u>
Plant E	200,000	2 1/2¢	\$ 5 million
Plant D	160,000	3¢	\$ 4.8 million
Plant C	120,000	3 1/2¢	\$ 4.2 million
Plant B	80,000	4¢	\$ 3.2 million
Total running cost of thermal plants			\$ 17.2 million

Saving of running cost = \$ 3.2 million/year

Capital cost of Plant E @ \$600/KW × 50 MW = \$ 30 million

Readers should be aware that the peak-time “prices” that we calculate here do not in any way have to be put into practice (i.e., be actually collected from the power company’s customers). They really are measures of the actual economic cost of bringing peak-time energy in line by way of constructing plant E. Our \$4.5 million figure reflects the economic cost of the capital invested in plant E. If plant E only worked at peak-time one would have to assign this full \$4.5 million of capital cost to the peak period. In our case, the bulk of this cost is being covered by savings of running cost during the off-peak period. The peak-time price we calculated represents the remaining part of this cost, and thus reflects the true cost of supplying peak-time energy via the investment in plant E.

Thus we would use the peak-time prices that we have calculated to measure the benefits of a daily reservoir project’s adding to the supply of energy at a system peak of 1000, or the benefits of a seasonal hydro project’s increasing the supply of energy during a system peak of 1600 hours. The underlying purpose of our calculating peak-time prices based on thermal costs is therefore to give us a cost-based way of assigning a value to peak-time energy coming from alternative sources of energy.

18.7 Thermal Capacity That Differs by Type of Plant

In this section we will consider differences in the capital and running costs of thermal plants, based on their physical (engineering) characteristics. For simplicity, we will confine our examples to three types of facility -- big thermal, combined cycle and gas turbine. There used to be many more relevant variations by type, as there would be significant variations in capital and running costs for coal-fired plants of different sizes. This sort of variation has been greatly reduced as a consequence of the introduction of combined cycle generating plants. These plants use petroleum or natural gas as fuel, and use jet engines or similar equipment to generate energy in the first cycle. The second cycle then uses the heat produced in the first cycle in order to create steam, which then produces additional energy in the second cycle. Once combined cycle technology came onto the scene, it turned out to be the cheapest way of generating electricity under a very

substantial range of demand conditions. Thus our choice of just three types of generating equipment pretty well reflects the realities of contemporary thermal power industries.

The characteristics of our three types of equipment are:

	Capital Cost (K)	Annualized Capital Cost (= $.15 \times K$)	Running Cost
Big Thermal	\$2000/KW	\$300	\$200 per KW/yr
Combined Cycle	\$1200/KW	\$180	5¢ per kWh
Gas Turbine	\$ 600/KW	\$ 90	9¢ per kWh

Readers will note that the running costs of big thermal are expressed on an annual basis per KW of capacity, rather than on a per-kilowatt-hour basis. The reason for this is that big coal-fired units cannot be turned on and off to meet variations in system demand. As is the case with nuclear capacity, turning them on and off is a costly operation, leading to their characteristic use as baseload capacity which only gets turned off for maintenance and repairs.

Table 18.3 examines the total annual costs of using these three types of capacity in order to meet different durations of energy demand. It is easily seen there that big thermal is the most efficient way to meet an annual energy demand (per KW of installed capacity) lasting 7500 hours, while combined cycle is best for a demand covering 5000 hours in the year, and also for one covering 3000 hours. For demands lasting 2000 and 1000 hours, however, gas turbines provide the most efficient answer.

Table 18.3
Electricity System Investment Decision as with
Three Different Types of Generating Capacity

	<u>Annualized</u> <u>Capital Costs/KW</u>	<u>Running Costs</u> <u>Per Year</u>	<u>Total Costs/KW</u> <u>Per Year</u>
<u>Use for 7500 hours/yr.</u>			
Big Thermal	\$300	\$200	<u>\$500</u>
Combined Cycle	\$180	$5¢ \times 7500 = \$375$	\$555
Gas Turbine	\$90	$9¢ \times 7500 = \$675$	\$765
<u>Use for 5000 hours/yr.</u>			
Big Thermal	\$300	\$200	\$500
Combined Cycle	\$180	$5¢ \times 5000 = \$250$	<u>\$430</u>
Gas Turbine	\$ 90	$9¢ \times 5000 = \$450$	\$540
<u>Use for 3000 hours/yr.</u>			
Big Thermal	\$300	\$200	\$500
Combined Cycle	\$180	$5¢ \times 3000 = \$150$	<u>\$330</u>
Gas Turbine	\$ 90	$9¢ \times 3000 = \$270$	\$360
<u>Use for 2000 hours/yr.</u>			
Big Thermal	\$300	\$200	\$500
Combined Cycle	\$180	$5¢ \times 2000 = \$100$	\$280
Gas Turbine	\$ 90	$9¢ \times 2000 = \$180$	<u>\$270</u>
<u>Use for 1000 hours/yr.</u>			
Big Thermal	\$300	\$200	\$500
Combined Cycle	\$180	$5¢ \times 1000 = \$50$	\$230
Gas Turbine	\$ 90	$9¢ \times 1000 = \$90$	<u>\$180</u>

Borderline between big thermal and combined cycle

$$\$300 + \$200 = \$180 + .05 N_1$$

$$\$320 = .05 N_1$$

$$6400 = N_1$$

Borderline between combined cycle and gas turbine

$$\$180 + .05 N_2 = \$90 + .09 N_2$$

$$\$90 = (.09 - .05) N_2$$

$$2250 = N_2$$

If different types of capacity are best for different numbers of hours, there have to exist critical numbers of hours marking the “borderline” between two types. These borderlines are found by equating the total costs for two adjacent kinds of capacity. Thus at 6400 hours the total annualized cost of combined cycle capacity is equal to $\$180 + \$.05(6400) = \$500$, exactly the same as the full-year cost ($\$300 + \200) of a KW of big thermal capacity. Demands with durations longer than 6400 hours can thus be accommodated most cheaply by big thermal capacity, while new demands lasting somewhat less than 6400 hours can be more efficiently served by combined cycle capacity. These answers apply (a) when the new demand stands alone (i.e., when we are building capacity just to satisfy this demand) and (b) when the new demand is added to an already optimized system.

In an exactly analogous fashion we can find that the borderline between combined cycle and gas turbine (GT) capacity is 2250 hours. For this number of hours, total annual costs of combined cycle capacity amount to $\$180 + (2250 \times 5\text{¢})$, or $\$292.50$, exactly the same as the annual total for GT at capacity, equal to $\$90 + (2250 \times 9\text{¢}) = \$90 + 202.50 = \$292.50$. So again, either for a stand-alone demand or for a new demand within an already optimized system, we would install GT capacity for demands lasting less than 2250 hours, and combined cycle capacity for demands going up from this point.

Table 18.4 explores cases in which capacity is being added to an already optimized system. The first step is to identify system marginal costs -- these are equal to 3¢/kWh , the marginal running costs of big thermal, when it is the most expensive capacity at work (i.e., during hours of quite low system demand). Similarly, system marginal costs equal 5¢/kWh when combined cycle is the most expensive capacity at work (i.e., during periods of intermediate system demand). Then we have system marginal costs equal to 9¢/kWh when gas turbine capacity is marginal. There are times when the system’s big thermal and combined cycle plants are all operating at full capacity, and therefore have to be supplemented by gas turbines in order to accommodate the system’s full demand. The

system marginal cost of 9¢ occurs when this is the case and when the system's gas turbine capacity is not fully utilized -- i.e., when the system is not yet at peak demand.

Now consider the fact that if gas turbine plants were to generate revenues of 9¢ per kWh for all their hours of operation, this would just cover their running costs, but would make no contribution to their capital costs. Thus, just as in the first part of this chapter, the peak-time surcharge was in the first example set at 6¢ and a thermal peak surcharge in a later example was set at 3¢ in order to cover the annualized capital cost of new homogeneous thermal capacity, we now set a peak-time surcharge of 9¢, in order to cover the annualized \$90/KW capital costs of gas turbine capacity, over a system peak of 1000 hours per year.⁴

In Table 18.4 we deal with three cases, each dealing with how the system should respond to a new set of energy demands – Case #1 considers a new demand with a duration of 7000 hours per KW per year; Case #2 considers a new demand lasting 4000 hours; and in Case #3 the new demand has a duration of 1500 hours. These cases illustrate how, in an optimized system of the kind we are working with, (a) each new demand can be met by its appropriate type of capacity, and (b) when this is done and that new capacity is remunerated at system marginal cost for each hour that it runs, the total remuneration precisely covers the sum of annualized capital costs plus annual running costs for the appropriate type of capacity.

Thus, in Case #1, big thermal is the “right” capacity to meet a new demand for 7000 hours a year. If it earns system marginal costs, it will get 18¢/kWh during 1000 peak-time

⁴When we deal with peak-time, we act as if the relevant capacity (here gas turbines) is absolutely fully utilized over the assumed duration (here 1000 hours) for peak demand. In reality, an electricity administration would define peak-time hours in a very sensible way (say 5-11 p.m. for a lighting peak in winter, 8-11 p.m. in summer) fully recognizing that the GT part of the system would not be operating at absolutely full capacity during these times. The rest of the system (big thermal and combined cycle) would, however, be at full capacity. Setting the peak-time surcharge at precisely 9¢ turns out to “right” from the standpoint of big thermal and combined cycle capacity as is shown in Table 18.4. It is also “right” from the standpoint of GT capacity if it is indeed fully used for the low hour peak. This is what we assume here. An upward modification of the peak-time surcharge would lead to excess rewards for big thermal and combined cycle.

hours, 9¢/kWh during 1250 hours, 5¢/kWh during 3750 hours, and finally 3¢/kWh during the 1000 hours when big thermal is the system's marginal capacity. As is shown for Case #1 remuneration at these marginal costs will precisely cover by thermal's annualized capital costs of \$300/KW plus its annual running cost (at 7000 hours) of $7000 \times 3¢ = \$210/\text{KW}$.

Similarly, in Case #2 we have combined cycle capacity being built to accommodate a new demand lasting 4000 hours per year. Here remuneration at system marginal cost covers 1000 hours at 18¢ plus 1250 hours at 9¢ plus 1750 hours at 5¢ per kWh. The total of these "earnings" is \$380 per KW per year, which precisely equals the sum of an annualized capital cost of \$180/KW plus a running cost of 5¢/kWh for 4000 hours in the year.

Finally, Case #3 explores a new demand lasting 1500 hours, and met by adding new gas turbine capacity. Here that capacity "earns" 18¢/kWh for 1000 hours and 9¢/kWh for 500 hours for a total of \$225/KW per year. Once again, this amount precisely covers the GT annualized capital cost of \$90 per KW plus the GT running cost of 9¢/kWh for 1500 hours per year.

It almost looks like a "miracle" that a single peak-time surcharge turns out to be the only supplement to system marginal running cost that is needed, in order to fully cover both capital and running cost of each type of capacity in a fully optimized system. Perhaps with an excess of zeal we have called this proposition "the fundamental theorem of modern electricity pricing". At any rate, it was a noteworthy discovery in the annals of electricity economics.

Table 18.4
Investment Policy in a System with Optimized
Capacities and System Peak of 1000 Hours

System Marginal Costs

Big Thermal Capacity -- Operates for 6400 hours or more. System Marginal Costs when Big Thermal Operation is the marginal capacity = zero.

Combined Cycle Capacity -- Operates for more than 2250 hours and less than 6400 hours when this is the system's marginal capacity. System marginal costs = 5¢/kWh.

Gas Turbine Capacity -- Operates for less than 2250 hours per year. When this capacity is only partially used (not at system peak), system marginal costs = 9¢/kWh.

Peak-time Surcharge -- Sufficient to cover capital costs of gas turbine capacity during 1000 hours of system peak. Annualized capital costs of \$90.00 ÷ 1000 peak-time hours = peak-time surcharge of 9¢/kWh. System marginal cost during 1000 peak-time hours = 9¢ running cost + 9¢ peak-time surcharge = 18¢/kWh.

Case #1: New demand arises (new factory working 3 shifts per day), operating for 7000 hours per year.

<u>Answer:</u> build big thermal capacity to meet this demand	
“earns” 18¢/kWh during 1000 peak-time hours	= \$180
“earns” 9¢/kWh during 1250 hours when gas turbine is marginal capacity	= \$112.50
“earns” 5¢/kWh during (6400-2250) = 4150 hours when combined cycle is marginal capacity	= \$207.50
“earns” zero during 1000 hours when big thermal is marginal capacity	= 0
Total “earnings”	= \$500

Cost of this new capacity = \$300 annualized cap. cost + \$200 running cost = \$500

Big thermal's costs are exactly covered by system marginal costs including peak-time surcharge.

Table 18.4 (continued)

Case #2: New demand arises (new factory working 2 shifts per day), operating for 4000 hours per year.

<u>Answer:</u> build combined cycle capacity to meet this demand	
“earns” 18¢/kWh during 1000 peak-time hours	= \$180
“earns” 9¢/kWh during 1250 hours when gas turbine is marginal capacity	= \$112.50
“earns” 5¢/kWh during (4000-2250) = 1750 hours	= \$87.50
Total “earnings”	= \$380
Cost of this new capacity	= \$180 annualized capital cost
+ 5¢ × 4000 hours	= \$200 running cost
	= \$380

Case #3 -- New demand arises (population growth leads to new residential demand plus commercial and street lighting), operating for 1500 hours per year.

<u>Answer:</u> build gas turbine capacity to meet this demand	
“earns” 18¢/kWh during 1000 peakload hours	= \$180
“earns” 9¢/kWh during 500 hours when gas turbine is marginal capacity	= \$ 45
Total “earnings”	= \$225
Cost of this new capacity (= \$90 annualized capital cost)	
+ 9¢/kWh during 1500 hours	= \$225

As we shall see, a system which follows the rules of marginal cost pricing will tend over time to approach an optimized level. But many of the world's systems fall far short of this point at the present time and probably will still be non-optimized for quite some time into the future. In most of these cases the non-optimality of the system stems from two sources – (a) the presence of older steam and gas turbine plants that will naturally be retired as they live out their economic lives, and (b) the fact that combined cycle technology has not had enough time to reach the levels needed for a fully optimized system. Table 18.5 explores two cases, both dealing with a system that does not have its optimal amount of combined cycle capacity. These cases deal, respectively, with increases of demand of long (7000 hours) and short (1000 hours) duration. These new demands would “normally” (i.e., in a fully optimized system) be met by adding, respectively, big thermal capacity (for the 7000 hour increment of demand), and gas turbine capacity (for the 1000 hour increment). However, because of the non-optimality of the system, it turns out that the best response, even to these very long-duration and very short-duration increments of demand, is to add combined cycle capacity. This strategy is not only the cheapest way of accommodating the new demands; it also moves the system closer to optimality.

In Case #4, the new demand has a duration of 7000 hours. At first glance it seems natural that this demand should be filled by big thermal, which is the most efficient type of capacity for demands of this length. That is true in an optimized system. But in a non-optimized system we may already have some big thermal capacity doing what it shouldn't (optimally) do. This is true in our Case #4, where we have some big thermal capacity that is meeting demands of only 4500 hours a year. The right answer is to shift this big thermal capacity out of this slot (where it doesn't belong), to move it to the new 7000 hour slot (where it does belong) and to replace it in the 4500 hour slot by combined cycle capacity, which is optimal for that duration. As the table shows, this set of moves meets the new demand at a total (capital plus running) cost that is lower than the cost of meeting the new demand with new big thermal capacity.

Table 18.5

**Investment Policy in a Non-Optimized System
With “Too Little” Combined Cycle Capacity**

- System has “too much” big thermal capacity, which ends up satisfying demands of 4500 hours or more.
- System has “too much” gas turbine capacity, which ends up satisfying all demands of 3000 hours or less.
- System has “too little” combined cycle capacity, which ends up satisfying demands between 3000 and 4500 hours per year. Recall that, combined cycle capacity has an economic advantage (based on capital and running costs) for demands all the way from 2250 to 6400 hours per year. So quite naturally, if a new demand arises within the 2250-6400 range, it should be filled by adding combined cycle capacity. However, owing to the non-optimality of the system, it turns out that the answer to any increase in demand is to add combined cycle capacity, as this brings the system closer to an optimum. The following examples show why this is so.

Case #4 -- New demand arises for 7000 hours per year.

Answer: Meet this demand by taking away big thermal from its “margin” at 4500 hours per year and shifting it to satisfy the new demand of 7000 hours. No capital cost or marginal running cost is involved since this capacity operates full time in either case.

Now add combined cycle capacity to fill the void of 4500 hours created by shift. This entails \$180 of annualized capital cost plus $4500 \times 5¢ = \$225$ of additional running cost = \$405

Total Cost of meeting new demand = \$405

Total cost of meeting this new demand by directly building big thermal capacity for this purpose = \$300 annualized capital cost plus \$200 of annual running cost = \$500

Hence -- It is cheaper to add combined cycle than to install new big thermal capacity to meet this new demand.

Table 18.5 (continued)

Case #5 -- New Demand arises for just 1000 hours of peak (say commercial establishments adding to demand for lighting during evening hours).

Answer: Meet this demand by taking away gas turbine capacity from its “margin” of 3000 hours and shifting it to meet the new peak-time demand of 1000 hours. No capital cost, and there is a saving of running cost of $(3000-1000) = 2000$ hours $\times 9\text{¢/kWh}$ = -\$180

However, we now have the capital cost of combined cycle (= \$180) plus (running costs combined cycle (= $3000 \times 5\text{¢}$) = \$150 for 3000 hours
Total combined cycle cost = \$330

Net cost per KW of building combined cycle to meet the new demand = \$150

Total cost of meeting the new demand by directly building GT capacity for this purpose = \$90 of capital cost + $9\text{¢} \times 1000$ hours = \$90 of running cost, for a total cost of = \$180

Hence, it is cheaper to add combined cyclical than to install new gas turbine capacity to meet the new demand.

Similarly, we have Case #5, of a new demand with a duration of just 1000 hours. This is taken to be at peak-time, because if it were away from the peak this new demand could be met by simply making more intensive use of the system's existing capacity.

Here the casual observer might think that the best way to respond to the new demand would be to add new gas turbine capacity. Again, this would be the right answer if the system was starting from an optimized position. But given the non-optimality of having some GT capacity working as long as 3000 hours, the best answer is to shift this GT capacity to the new 1000-hour slot. This saves $9¢ \times 2000$ hours of GT running cost per KW of shifted capacity. To replace this shifted GT capacity in the 3000 hour slot, we introduced new combined cycle capacity, having an annualized capital cost of \$180 and an annual running cost of \$150 ($= 3000 \times 5¢$). The total cost of this combined cycle operation is \$330 per year, but deducting the saving of running cost on the shifted GT capacity, we find a net cost of $\$330 - \$180 = \$150$. This is obviously lower than the \$180 cost of satisfying the new 1000 hour demand by adding new gas turbine capacity.

Cases #4 and #5 show why it is true that in a non-optimized system that has too little combined cycle capacity, adding to that particular type of capacity will be the cost-minimizing way of responding to new demands of essentially any duration.

18.8 Some Notes on Solar and Wind Power

The right way to think about solar and wind power is to consider them as the modern counterparts of run-of-the-stream generation. All of these have the characteristic that the ultimate source of energy experiences natural variations that are beyond our direct control. In the case of run-of-the-stream projects, we have the possibility of adding daily reservoirs, at which point we do control the flow of energy into the system. The counterpart of daily reservoirs would be to use wind or solar energy to pump water from a lower to a higher level, with the intention of generating electricity through hydro turbines during peak-time hours. This is known as pump storage, and involves two dams,

one above and the other below the incline down which the water flows to the turbines. Pump storage projects have existed at least since the 1930s, but they have not become very widespread because of the heavy capital costs that they involve. Aside from pump storage, another means of controlling the flow of electricity from wind and solar sources would be through batteries -- generate electricity as the wind and sun permit, but use batteries to store that energy, so that it can be used at times of high value per kilowatt hour. To our knowledge, such use of batteries is still far from being cost-effective.

Thus our discussion of wind and solar energy will concentrate on the standard case, directly analogous to run-of-the-stream projects, where the electricity generated by the project is delivered to the system at the time and in the volume determined by the whims of nature.

Solar and wind projects differ from run-of-the-stream operations in that one does not always encounter diminishing returns to adding turbines or solar panels at a given site. Ten solar panels will catch ten times as much sunlight as one panel, and ten turbines will catch ten times as much wind as one of them (with some exceptions in cases of canyons, etc. which channel the wind in special ways). The generating capacity of solar and wind projects will therefore be determined mainly by the costs of installing more turbines or panels, and by the needs of the electricity system.

The standard way of dealing with capacity of these kinds is to assign to their output the relevant system marginal costs. Reverting to our example of Table 18.4, suppose a solar or wind project had a maximum output of 10MW. To value its expected output for any future year we would first assign system marginal costs for each hour of operation. Thus, following Table 18.4, we would have 2360 (= 8760 - 6400) hours at zero marginal cost (when big thermal was expected to be the marginal capacity), 4150 hours at 5¢ (when combined cycle was expected to be at the margin), and 2250 hours at 9¢, the marginal running cost of gas turbine capacity. These add up to \$410 per KW per year. However, the solar or wind project would be expected to operate only at a fraction of its capacity,

owing to fluctuations in the availability of wind and sunlight. We here assume the relevant fraction to be 30%, which reduces the benefit to \$123 per KW of capacity.

The above calculations assign no part of the peak-time surcharge to the wind or solar project. This is because in both cases there are likely to be many peak-time hours during which the project will have zero output. In order to meet peak-time demand at such times, some sort of other standby capacity would have to be available. This might consist of older capacity, mainly retired from the system but held for standby purposes for just this kind of contingency. But within the framework of Table 18.4, it would be gas turbine capacity. There may be places where the wind or sun is so reliable that it can be counted on, at a specified intensity, in peak-time hours. If we assume that intensity to be 20% of the maximum intensity, then we would add to the above figure of \$123, an amount equal to 20% of the 9¢ peak-time surcharge, times the 1000 hours of peak-time use. This would add \$18; for a total benefit of \$141 per KW.

Some discussions of wind and solar power speak of a “necessity” of supplementing these projects with backup peaking capacity (which in our case would be gas turbines). These discussions focus on the unreliability of these sources to provide peak-time power. The backup capacity enters the picture in order to fill precisely this role. We feel that such “packaging” is unnecessary. In coming to this conclusion we rely on a fundamental principle of project evaluation -- namely, the principle of “separable components”. This principle says that if we have two projects X and Y, we can define their combined benefit (in present value) as B_{X+Y} , their separate, stand-alone benefits as B_X and B_Y and the benefits of each, conditional on the presence of the other, as $B_X|_Y$ and $B_Y|_X$. It is easy to see that:

$$B_{X+Y} = B_X + B_Y|_X = B_Y + B_X|_Y$$

Similarly, for costs:

$$C_{X+Y} = C_X + C_Y|_X = C_Y + C_X|_Y$$

Now if the “joint project” (X+Y) is the best option, this means that

$$(B_{X+Y} - C_{X+Y}) > (B_X - C_X)$$

$$(B_{X+Y} - C_{X+Y}) - (B_X - C_X) > 0$$

and therefore $B_Y|_X > C_Y|_X$.

That is, if the joint project is acceptable, project Y must pass the test as the marginal project -- it must be worthwhile to add project Y to an initial package consisting only of project X.

Similarly, it can be shown that if the joint project is best, project X must pass the test as the marginal project -- it must be worthwhile to add project X to an initial package consisting only of project Y.

There is no escaping the rigorous mathematical logic of this argument. If a package consisting of a wind project and a backup GT project is the best option. Then each of these two components must pass the cost-benefit test as the marginal project, measuring its contribution as what it would add (to benefits and costs, respectively) in the presence of the other. We therefore must evaluate a wind or solar project as being additional to any GT or other standby peaking project with which some would argue it ought to be “packaged”.

18.9 Conclusion

The main objective of this chapter is to convey an understanding of the underlying economic principles that characterize the provision of electric energy. The starting point is that the value of the kilowatt hour -- the standard “product” that electricity customers buy and consume -- will normally exhibit wide variations by hour of the day and season of the year. This occurs in spite of the fact that there is probably no item more physically homogenous from unit to unit than kilowatt hours of 120 volts and 60 cycles. The reason for the variation in value stems from different effective marginal costs of providing energy at different times. When an electricity system is not working at capacity, the effective marginal cost is the highest running cost among the different plants that are

operating at the time. As plants are turned on, in ascending order of running cost, the effective marginal cost will be low at times of low demand, and high at times of heavy demand on the system's resources. System marginal cost is highest at peak periods, because here the true cost must also cover a provision for capital cost recovery of the type of capacity that has to be expanded when peak-time demand increases.

The key to evaluating investments in new generating capacity is to value their expected output at "system marginal cost", at each moment they are expected to operate. Put another way, the benefits that are to be expected from a new plant are the costs that will be saved due to its presence in the system. This is something that seems straightforward and easy to understand, but in fact it is anything but simple. The subtleties arise because the output of a new plant stretches many years into the future, so the bulk of its cost-saving will take place then. The principle guiding the estimation of these future cost savings is that year by year and into the future, the system will continue to follow good cost-benefit principles as it retires old plants and invests in new ones. Any given plant will almost certainly have a trajectory of benefits that starts high, and then declines over time. For thermal plants, one can expect that future additions will be more efficient than the current ones, so that today's new plant, which may start as the most efficient one of its class, may end its life as the least efficient of the class, having been bumped from a heavy load factor (high hours of use) at the beginning of its life to lower and lower hours of use as time goes on. Finally, it will be relegated to standby capacity, and ultimately to the scrap heap. Hydro storage dams have a similar trajectory of benefits, in this case stemming from their inevitable accumulation of mud and silt. As this occurs, their effective storage capacity inevitably declines. Perhaps run-of-the-stream projects and daily reservoirs (which can be desilted quite easily) are the only ones whose benefit streams may escape an inevitable downward drift through time.

The downward trend of benefits of a given project is incorporated in our analysis via an allowance for depreciation. Investment in an asset that does not depreciate can be justified if that asset just yields the required rate of return (opportunity cost of capital). It is the expectation of declining (or ultimately terminating) benefits that leads to first-year

benefits covering more than the required rate of return. The use in our exposition of a required rate of return-plus-depreciation in the first year of a project's operating life is intended to capture all of the subtleties referred to in this note.

The fact that the future benefits of electricity projects are measured by their expected savings of costs gives rise to another possibility -- that the electricity system in question may have already in place a modern and highly sophisticated system of cost control and future investment programming. That is to say, those enterprises or public authorities may already have done a lot of the work needed in order to see how a given new plant will fit into the system, and which particular costs it will likely be saving, hour by hour and year by year, at least for a few years into the future. All we can say here is that, as cost-benefit analysts, we should be grateful when such pieces of luck relieve us of a great deal of work!!

**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 19:**

*AN INTEGRATED APPRAISAL OF COMBINED CYCLE VERSUS SINGLE CYCLE
ELECTRICITY GENERATIONS TECHNOLOGIES*

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ABSTRACT

This study undertakes an integrated financial, economic and distributive appraisal of an Independent Power Producer (IPP) project to generate electricity. The critical issue is that the private sponsors of the IPP have proposed to build a single cycle electricity generation plant that is expected to start operating with an 80 percent load factor. A comparative analysis is undertaken a single cycle oil fuel plant to compared to a combined cycle oil fuel plant that would produce the same amount of electricity per year. This analysis is made from the point of view of each of the major stakeholders affected, namely the sponsor of the IPP, the public utility that is the off-taker of the electricity, the government and consumers.

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CHAPTER 19

AN INTEGRATED APPRAISAL OF COMBINED CYCLE VERSUS SINGLE CYCLE ELECTRICITY GENERATIONS TECHNOLOGIES

19.1 Introduction

This study undertakes an integrated financial, economic and distributive appraisal of an Independent Power Producer (IPP) project to generate electricity. The critical issue is that the private sponsors of the IPP have proposed to build a single cycle electricity generation plant that is expected to start operating with an 80 percent load factor. A comparative analysis is undertaken a single cycle oil fuel plant to compared to a combined cycle oil fuel plant that would produce the same amount of electricity per year. This analysis is made from the point of view of each of the major stakeholders affected, namely the sponsor of the IPP, the public utility that is the off-taker of the electricity, the government and consumers.

19.2 Background

The energy sector in Adukki for a long period of time has relied mainly on the generation capacity of the hydroelectric power plants.¹ Almost 61% of the installed capacity is currently hydro and the rest thermal. All the hydro power plants are owned by the Adukki Electricity Corporation (AEC), the state owned utility which generates power and handles all the transmission and distribution of electricity in the country. Heavy reliance on hydroelectric power generation has caused shortages in meeting the demand for power during periods of drought when the water level in the reservoirs is very low. In addition, the current power generation capacity is not sufficient to sustain higher economic growth prospects, leading to a power deficit. The main challenges faced by the energy sector are further diversification of the source of electricity generation as well as expansion of the total installed capacity.

¹In order to maintain the confidentiality of the information of the original project from which this case was built the name of the country, the currency and a number of elements have been changed. Over the past three years 2006-2008, Adukki has achieved an average real GDP growth rate of slightly above 6% yearly. Estimations indicate that the rate of growth would have been 0.7% to 0.9% higher if electricity shortages did not prevail in the recent years. Adukki is aiming to achieve a real GDP growth rate of 7-10% annually by year 2015 and to position itself as a middle-income country with a per capita income of US\$1,000. Furthermore, the current access to electricity by the population is only slightly over 50%. If the government wants to achieve 100% national electrification by 2030, this would require the current installed capacity to be doubled by 2030 in order to insure a reliable and sufficient electricity supply.

The potential for power capacity expansion is perceived by the private sector as a profitable opportunity to invest. A proposal has been made to the Government of Adukki (GOA) by Bright Light Electricity Generation Ltd (BLEGL) to finance, construct, operate and maintain an IPP called Bright Light Electricity Generation project (BLEG). This project aims to build a 126 MW single cycle gas turbine plant, which is expected to be operational by 2010 and will be located at the site owned by the government. In addition, the utility will supply the required fuel for the operation of the plant, which will be Light Crude Oil (LCO). The total cost of investment (net of VAT) is estimated to be almost US\$134 million. Upon completion, the IPP will add 126 MW of additional capacity to the existing system. The AEC will be the sole off-taker of the generated power. A long-term Power Purchase Agreement (PPA) is to be signed by the parties.

BLEGL has approached the Regional Development Bank (RDB) and other senior lenders to find an affordable source of finance to cover 70% of the U.S. dollar denominated investment cost of the proposed project. The objective of this study is to assess whether the proposed investment is financially and economically viable, using an integrated appraisal framework that covers the evaluation of the financial, economic, stakeholder and risk aspects of the project in a consistent manner.

The base scenario is a stand-alone evaluation of the proposed IPP single cycle power plant. The proposal is made by the Currevolt Center for Electricity Distribution (CCED), which includes both CCED Inc. incorporated in the U.S. and CCED Ltd in Adukki, to the Government of Adukki to finance, procure and construct a single cycle plant. This project developer (CCED) has registered a company in Adukki called BLEGL as the investment vehicle to execute the proposed IPP. The financial benefits of this initiative will be measured in terms of the revenue generated from the PPA with the electric utility.

From the utility's perspective, however, the feasibility of the system expansion will be evaluated under two alternative scenarios. First, the project is evaluated if the IPP implements a singlecycle plant as proposed. Second, the same analysis is carried out if there are alternative technologies for expanding the electricity generation capacity. In this case, the alternative under consideration is a combined cycle plant using the same fuel type as proposed by the single cycle plant. This analysis will serve two purposes: to identify the most efficient technology

between the single and combined cycle technology from the utility's perspective as well as to foresee the potential impact of the technology choice on the electricity tariff.

The financial benefits generated from the utility are measured by the amount of electricity purchased from the IPP and then sold to end-users. The configuration of the generation plants has been made in this case in order that the same amount of electricity is generated no matter which technology is chosen. Comparison between technologies can be determined by the difference between the capital cost and the energy transformation efficiency of the alternative technologies employed. The integrated appraisal framework allows analysts to build a model directly on the consolidated financial cash flows statement which combines the cash flows of the IPP as well as those of the utility into a single statement.

The economic analysis in this case is an evaluation of the economic value of all of the costs saved by using one technology or the other. Either one of the options considered here will supply electricity to those consumers who currently are receiving either no electricity or an unreliable service, hence, the economic benefit must be tied to the relative costs of producing electricity. A key consideration in the choice of technologies is the determination of the least cost method to supply the needs of the utility given the present set of generation facilities available and the nature of the growth in electricity demand. It is also interesting to compare the costs of production to the valuation that demanders (on the margin) place on the incremental electricity generated due to the particular electricity pricing structure being used.

19.2.1 Project Costs of the Single Cycle Plant

The construction of the proposed 126 MW single cycle plant starts in 2008. This phase is expected to last for two years. It is anticipated that 56% of the cost will be incurred in 2008 while the remaining 44% will be spent the following year. The detailed expenditure incurred by component is shown in the Table 19.1.

**Table 19.1: Single Cycle Power Plant Investment Costs by Component,
(millionUS\$ in 2008 Prices)**

	2008	2009	Total
Land	0.50	0	0.50
EPC & Engineering			
Initial Operating Tools & Mobilization	2.65	2.08	4.73
GT Turbine & Related Costs	21.88	17.20	39.08
Total EPC Contract (excluding VAT)	28.99	22.78	51.77
Other Costs	3.96	3.12	7.08
Sub-Total	57.49	45.17	102.66
Development Costs (excluding VAT)	8.02	6.30	14.32
Financing Costs	9.24	7.26	16.50
Total Investment Cost	75.25	58.73	133.98

19.2.2 Project Financing

BLEGL proposes that the investments be financed 30% by equity and 70% by a loan from the RDB on a project finance basis. The loan will be disbursed in year 2008 and 2009, covering 70% of the respective dollar-denominated investment costs incurred in each year.

The loan principal is to be repaid in 14 equal installments after a two-year grace period. Interest is paid on the balance of the loan remaining from the previous year. During the construction period the interest is paid and it is considered to be depreciated for tax purposes for a period of 5 years. The annual interest rate to be charged by the bank is set at a real rate of 6%.

19.2.3 Power Purchase Agreement (PPA)

The proposed plant will be located near to other thermal plants, which are currently owned and operated by the AEC. This location is advantageous in terms of access to water, electric transmission and fuel storage facilities. The type of fuel to be used by the plant is Light Crude Oil, which is imported.

The most important aspects of the proposed IPP and related contracts are summarized below:

- The AEC will be the only off-taker of the electricity generated by the proposed plant.
- A PPA is expected to be signed between the two parties. The tariff paid under the PPA by the AEC will be determined by three components (details of each component are specified in Section 19.2.2):

- *A capacity payment component* is a fixed amount designed to cover the capital recovery as well as fixed operating and maintenance costs.
 - *An availability incentive payment* is provided as a means of motivation so that the average availability factor of the plant in a given period does not fall below a specified availability factor. If it is above the target, a specific extra payment is to be made to the IPP based on each percentage point of excess availability. On the contrary, a penalty applies to the IPP.
 - *A variable operation and maintenance cost component* is a specific payment per MWh of energy generated in a year, net of auxiliary usage.
- The required fuel, LCO, for the plant to operate will be purchased and supplied by the AEC.
 - The land where the project will be located is also provided by the government as a grant.
 - The supply contract is expected to be signed by BLEGL with Spark Power Generation Co. (SPG), which is an international company located in the U.S. This company will be responsible for designing, engineering and supplying to the port of Adukki, the gas turbine for the power plant. SPG will also be contracted for the field engineering services and performance testing.
 - The Engineering, Procurement and Construction (EPC) contract will be signed with CCED. The contract consists of delivering the combustion gas turbine from the port to the plant site, commissioning and testing it. It also includes designing, manufacturing, transporting, commissioning, testing and the warranty for all other plant equipment.

19.3 Financial Appraisal of the Proposed IPP

One of the important concepts in assessing an investment initiative is to measure the incremental impact that would occur over and above that which would have occurred in the absence of the initiative. The financial appraisal of the proposed single cycle power plant is carried out on an incremental basis in which the “with” and “without” project scenarios are identified. Under the “without” project scenario, the private investor would not build the single cycle plant. The AEC may expand its capacity in the future either through own generation or purchases from other IPPs. In the “with” project scenario, the private project developer implements the IPP single cycle plant. This plant did not exist in the past, therefore all the new assets are considered as incremental investment from the perspective of the IPP.

Since the electricity generated will be sold to the AEC the financial revenue of the IPP will be determined by the PPA agreement. The analysis focuses on the financial viability of the IPP investment alone. As for the utility, the overall incremental impact will depend on the difference between the additional revenue collected from the sale of the incremental electricity to end users and any extra cost incurred from purchasing this electricity from the IPP. The project from the perspective of the utility will be assessed at a later stage.

The financial appraisal of the project considers two perspectives, namely the lender's perspective and BLEG's perspective. For BLEG, the appraisal examines the ability of the project to generate enough cash to recover the investment costs and also earn a competitive return on equity. From the lender's perspective, the analysis focuses on the capability of the project to meet its debt repayment obligations.

The starting point of the analysis is to develop the financial cash flow statement of the project from the total investment (or the lender) point of view. It does not consider how the project is financed. This perspective enables the analyst to assess if the project has adequate cash flow to service the debt regardless of the source of project financing.

19.3.1 Project Parameters and Assumptions

The base case financial model for the single cycle IPP has been developed based on the following assumptions and parameters.

Investment Costs

- The total investment cost net of the VAT is US\$133.98 million in 2008 prices. Details are shown in Table 19.1.
- Of the above investment cost, land is given to the project as a subsidy by the government. At the end of the project's life, the land will be returned to the government.
- The liquidation values of all investment items other than land belong to BLEG and are included in the analysis.

Technical Parameters

- The rated plant capacity is 126 MW. The maximum plant availability is 91% leading to a maximum installed capacity of 114.66 MW. This is subject to annual deterioration at a rate of 2.5%. The average plant availability factor is assumed to be 89%.
- The initial plant load factor in 2010 is anticipated to be 80% but it is expected to decrease by 3.4% per year until it reaches 40% in year 2030.² The proposed thermal plant is expected to run in all hours of peak demand, also during the off-peak hours when it is dispatched. Considering both peak and off-peak operations the plant is expected to have a final load factor of 40% in 2030.
- 5% of the gross capacity available is used for auxiliary consumption.

Operating and Maintenance Costs

- The plant is expected to commence generating electricity in year 2010 with an operating life of 20 years. The operation and maintenance costs expected to be incurred during the project's life are both fixed and variable, presented below (expressed in 2008 prices).

(a) Fixed O&M Costs

- **Labor:** The wages bill of project is expected to amount to US\$2.08 million in 2010. It is projected that 90% of those hired will be skilled and the remaining 10% unskilled. The real wage rate is assumed to increase by 3% annually.
- **General Administrative Fees and O&M Costs:** The general administrative fees are predicted to be US\$0.406 million on a yearly basis (excluding VAT), while the O&M costs will be approximately US\$0.5 million per annum. These values will increase over time in real terms by 1.5% a year plus the general rate of inflation.
- **Long Term Service Agreements (LTSA) and Others:** The LTSA will cover the whole period of time that the project is operating. The annual fee to be paid by the project amounts to approximately US\$ 4.97 million. This amount includes the fixed portion of other services as well.

(b) Variable O&M Costs

- **Fuel:** This is the most important component of the variable operating costs. The quantity of fuel, LCO, required for the single cycle gas turbine plant is determined by the energy

²The annual average percentage decrease is calculated as $(PLF_{2030}/PLF_{2010})^{1/(2030-2010)}-1$. This is due to the fact that as more further generation plants are introduced that have lower running costs then this plant will be used for a fewer number of hours each year. In addition over time the marginal running costs of this plant will increase due to wear and tear over time.

transformation efficiency rate that is estimated to be 32%. This means that 32% of the heat energy released from combustion is converted into electricity. The remaining energy is dissipated in the form of heat. The amount depends on the fuel density/heat content that is 47,000 MJ per ton of fuel. The price of LCO is assumed to be US\$367 per ton or an equivalent of US\$49 per barrel. However, as stated earlier, the AEC is obliged under the PPA agreement, to supply the required amount of LCO to the proposed project. This makes AEC a stakeholder whose costs vary with the price of oil. We assume that ultimately the changes in costs paid by the AEC will be passed on to the consumers of electricity through changes in the electricity tariffs.

- ***Water, Chemicals and Lubrication Oil and LTSA &Others:*** The water needed for the operation of the plant will be obtained from the Adukki Water Company Ltd. The cost of water will be US\$0.000042 per kWh. The cost of lubrication oil for boiler together with the cost of chemicals is estimated at US\$0.00071 per kWh. Finally, the variable component of the LTSA costs and others is US\$ 0.00043 per kWh.

(c) Working Capital

- Accounts payable are expected to be 8% of the total operating costs excluding labor and fuel. The cash balance is projected at 5% of total annual operating costs excluding fuel.

Life of Assets and Residual Values

- All the investment cost items are expected to have an economic life of 25 years.
- Since the economic life of assets is longer than the project's operating life, there will not be any replacement of the assets during the plant's operation.

Macro-economic Variables

- The annual domestic inflation rate is expected to be 8.9% and for the U.S., it is 3%.
- The real exchange rate as of 2008 is 1.21 Rupees per U.S. dollar and remains unchanged, except when we undertake a sensitivity analysis.
- The value added tax rate in Adukki is 13%.
- The profit earned by the private investor is subject to the corporate income tax rate of 25%.

Required Rate of Return

- The minimum real rate of return required by the private investor is 13%.

19.3.2 Financial Viability of the IPP

The financial benefits of the project are determined by the PPA agreement with the AEC, which is the only off-taker of the electric power generated by the BLEG plant. The tariff payment under the PPA consists of three main components. The first one is a capacity payment based on the available capacity for sale to the off-taker. It includes the capital recovery payment as well as the payment to cover the fixed O&M costs. The second component is the availability incentive payment made when the availability factor of the plant is higher than the specified availability set at 85%. The last component includes the payment made to cover the variable operating and maintenance costs of the IPP except fuel, which is provided by the utility. The specific amount to be paid for each component is denominated in U.S. dollars and is described below:

- The capacity payment for the proposed plant is expected to be US\$295,000/MW/Year in 2008 prices (net of VAT). It is applied to the yearly net available capacity for sale and is indexed to the U.S. inflation.
- The availability incentive payment is set at US\$150,000 in 2008 prices per percentage point by which the availability factor exceeds the 85% target. The same figure applies as a penalty to the IPP for each percentage point of shortfall below this target. In both cases, it is indexed to the U.S. rate of inflation.
- The variable O&M cost component is estimated at US\$2.91 in 2008 prices (net of VAT) per MWh of metered electricity delivered to the AEC and is indexed to take account of the U.S. price level. The amount of energy sold to the AEC is measured by the net energy generation in the financial model.

Accounts receivable of the IPP is estimated to be 8% of the total PPA Revenue. Based on the above assumptions and parameters, the financial cash flow statement from the point of view of total investment is developed. This statement is of particular interest to the RDB, which is approached to finance 70% of the project's cost. As the principal project lender, the RDB wants to assess whether the projected net cash flows will be sufficient to cover the debt obligations. To facilitate this evaluation the project's expected debt service ratios are calculated.

The Annual Debt Service Coverage Ratio (ADSCR) measures the annual cash flows generated as a multiple of the scheduled annual debt repayment obligations. The values of this ratio range from 1.24 in year 2010, gradually improving year-by-year to end at 1.99 in the last year of debt

service. As Table 19.2 shows, only in the first year is the ADSCR slightly lower than 1.3, the required ratio by the RDB in the case of an off-taker contract. During the following years this ratio improves and is expected to be well above the lender's benchmark. This means that if there were no uncertainties, the project's cash flow during the debt service period would amply cover its annual debt obligations. However, in an uncertain environment, the base case ratios may not be realized.

The Loan Life Cover Ratio (LLCR) is defined as the present value of the expected net cash flow during the loan repayment period divided by the present value of the remaining debt service payments, discounted by the real interest rate charged on the loan. This ratio allows us to examine the strength of future cash flows beyond any specific years when the ADSCR is not satisfactory. The cash flow projections indicate that the LLCR is 1.51 in the first year of debt service and reaches 1.99 in the last year.

To sum up, based on the debt service ratios computed, the project's annual net financial receipts are projected in the base case analysis to be at least 24% higher than the scheduled annual loan repayment. In the first year of operation the present value of the stream of the future net cash flows over the loan repayment period is at least 151% of the present value of the total scheduled debt repayments.

**Table 19.2: Financial Cash Flow Statement from Total Investment Perspective
(million Rupees in 2008 prices)**

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2028	2030
Inflows																		
Total PPA Revenue	0.00	0.00	42.53	41.40	40.30	39.23	38.19	37.18	36.20	35.25	34.33	33.44	32.57	31.72	30.90	30.10	26.44	0.00
Change in Accounts Receivable	0.00	0.00	-3.40	-0.19	-0.18	-0.18	-0.17	-0.17	-0.16	-0.16	-0.16	-0.15	-0.15	-0.15	-0.14	-0.14	-0.12	1.89
Government Fuel Re- imbursement	0.00	0.00	76.97	72.64	68.57	64.73	61.11	57.69	54.47	51.44	48.57	45.88	43.33	40.93	38.67	36.53	27.55	0.00
Land Subsidy	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Residual Values																		
Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Other Assets	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.38
Total Cash Inflows	0.61	0.00	116.10	113.85	108.68	103.78	99.12	94.70	90.51	86.53	82.75	79.16	75.75	72.51	69.43	66.50	53.86	36.88
Outflows																		
Investment Costs																		
Land	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Other Investment Costs	96.26	75.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Operating & Maintenance Costs																		
Labor	0.00	0.00	2.67	2.75	2.83	2.92	3.01	3.10	3.19	3.28	3.38	3.48	3.59	3.70	3.81	3.92	4.55	0.00
O&M	0.00	0.00	8.26	8.24	8.22	8.20	8.19	8.18	8.17	8.16	8.16	8.15	8.15	8.15	8.15	8.15	8.18	0.00
Fuel Requirement Cost	0.00	0.00	76.97	72.64	68.57	64.73	61.11	57.69	54.47	51.44	48.57	45.88	43.33	40.93	38.67	36.53	27.55	0.00
Change in Working Capital	0.00	0.00	-0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Net VAT Liability	-5.82	-4.57	4.83	4.70	4.57	4.45	4.33	4.21	4.10	3.98	3.88	3.77	3.67	3.57	3.48	3.39	2.96	0.00
Corporate Income Tax	0.00	0.00	0.29	0.48	0.66	0.81	0.95	2.48	2.47	2.46	2.44	2.42	2.47	2.43	2.39	2.34	2.43	0.00
Total Cash Outflows	91.05	71.06	92.90	88.81	84.84	81.10	77.57	75.65	72.39	69.32	66.43	63.70	61.21	58.78	56.49	54.34	45.66	0.62
Net Cash Flow before Financing	-90.45	-71.06	23.20	25.05	23.84	22.67	21.55	19.05	18.12	17.21	16.32	15.46	14.54	13.73	12.93	12.16	8.20	36.26
Discounted PV of Net Cash Flow			189.47	176.25	160.27	144.62	129.26	114.17	100.83	87.68	74.70	61.88	49.21	36.75	24.41	12.16		
Discounted PV of Loan Repayment			125.47	113.12	101.38	90.22	79.63	69.58	60.05	51.01	42.45	34.34	26.68	19.42	12.57	6.10		

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ADSCR			1.24	1.43	1.47	1.50	1.54	1.47	1.52	1.57	1.62	1.68	1.74	1.81	1.90	1.99		
LLCR			1.51	1.56	1.58	1.60	1.62	1.64	1.68	1.72	1.76	1.80	1.84	1.89	1.94	1.99		

The private investor of this project is expected to receive a rate of return on its equity capital no less than the target real rate of return of 13%. This can be seen from the above annual financial cash flow statement adjusted for loan disbursements received and interest and principal paid. The resulting financial cash flow statement after financing is presented in Table 19.3 from the owner's perspective. It addresses the question of whether the flow of financial benefits over the lifetime of the proposed project is sufficient not only to cover capital and operating expenditures but also to provide an adequate rate of return on the owner's investment. This is accomplished by taking the financial NPV after financing using 13% real rate of return on equity as the discount rate. The financial NPV is estimated to be 0.37 million Rupees in 2008 prices. It implies that the private investor will be able to not only recover all the capital and operating costs but also earn more than a 13% real rate of return on his investment. The relevant internal rate of return (IRR) is 13.1%.

Based on the above analyses from both the total investment perspective and the owner's perspective, the participation of the private investor in the IPP appears to be financially viable and bankable.

It should be noted, however, that these financial outcomes are a result entirely because of the particular terms of the PPA agreement. As such, their realization will depend on the long-term viability of the PPA agreement from the perspective of AEC and its customers.

Table 19.3: Financial Cash Flow Statement from the Equity Owner's Perspective
(million Rupees in 2008 prices)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2028	2030
Inflows																		
Total PPA Revenue	0.00	0.00	42.53	41.40	40.30	39.23	38.19	37.18	36.20	35.25	34.33	33.44	32.57	31.72	30.90	30.10	26.44	0.00
Change in Accounts Receivable	0.00	0.00	-3.40	-0.19	-0.18	-0.18	-0.17	-0.17	-0.16	-0.16	-0.16	-0.15	-0.15	-0.15	-0.14	-0.14	-0.12	1.89
Government Fuel Re-imburement	0.00	0.00	76.97	72.64	68.57	64.73	61.11	57.69	54.47	51.44	48.57	45.88	43.33	40.93	38.67	36.53	27.55	0.00
Land Subsidy	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Residual Values																		
Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Other Assets	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.38
Total Inflows	0.61	0.00	116.10	113.85	108.68	103.78	99.12	94.70	90.51	86.53	82.75	79.16	75.75	72.51	69.43	66.50	53.86	36.88
Outflows																		
Investment Costs																		
Land	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
Other Investment Costs	96.26	75.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Operating & Maintenance Costs																		
Labor	0.00	0.00	2.67	2.75	2.83	2.92	3.01	3.10	3.19	3.28	3.38	3.48	3.59	3.70	3.81	3.92	4.55	0.00
O&M	0.00	0.00	8.26	8.24	8.22	8.20	8.19	8.18	8.17	8.16	8.16	8.15	8.15	8.15	8.15	8.15	8.18	0.00
Fuel Requirement Cost	0.00	0.00	76.97	72.64	68.57	64.73	61.11	57.69	54.47	51.44	48.57	45.88	43.33	40.93	38.67	36.53	27.55	0.00
Change in Working Capital	0.00	0.00	-0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Net VAT Liability	-5.82	-4.57	4.83	4.70	4.57	4.45	4.33	4.21	4.10	3.98	3.88	3.77	3.67	3.57	3.48	3.39	2.96	0.00
Corporate Income Tax	0.00	0.00	0.29	0.48	0.66	0.81	0.95	2.48	2.47	2.46	2.44	2.42	2.47	2.43	2.39	2.34	2.43	0.00
Total Cash Outflow	91.05	71.06	92.90	88.81	84.84	81.10	77.57	75.65	72.39	69.32	66.43	63.70	61.21	58.78	56.49	54.34	45.66	0.62
Net Cash Flow before Financing	-90.45	-71.06	23.20	25.05	23.84	22.67	21.55	19.05	18.12	17.21	16.32	15.46	14.54	13.73	12.93	12.16	8.20	36.26
Loan Disbursement	67.39	52.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Annual Loan Repayment	0.00	6.01	18.76	17.48	16.26	15.10	13.99	12.93	11.92	10.96	10.05	9.18	8.35	7.56	6.81	6.10	0.00	0.00
Net Cash Flow after Financing	-23.06	-24.12	4.44	7.57	7.58	7.58	7.56	6.12	6.19	6.24	6.27	6.28	6.19	6.16	6.12	6.06	8.20	36.26
FNPV @13%	0.37																	
FIRR	13.1%																	

19.3.3 Financial Sensitivity Analysis of the IPP

The results of the financial appraisal presented above are largely determined by the values of the parameters and assumptions based on the experience of similar power plants or by using experts' judgment whenever information is not available. However, it is natural to expect some degree of uncertainty and deviation from these values since the revenue and cost items will be incurred in the future. A sensitivity analysis is carried out to identify the critical parameters with the strongest effect on the project's outcome, including the financial NPV (discounted at real rate of 13 percent), the annual debt service coverage ratio and the loan life coverage ratio.

Investment Costs Overrun: Given that the main items of the capital expenditure are negotiated through the supply and EPC contracts, the likelihood of a cost overrun for the IPP is small. If a provision is to be made according to which the EPC contract price should be adjusted for any changes or additional work approved by both BLEGL and CCED, most likely the BLEGL will require a higher PPA price from the AEC in return. If this is the case, the increase in the investment cost will not affect the financial NPV of the IPP.

Load Factor: The load factor of the plant is the ratio of the average amount of energy generated relative to its capacity. In other words, it is a measure of the actual electricity generated during a specific time as compared to the maximum amount that could have been produced over the same period of time. In the base case scenario it is estimated that the initial load factor will be 80% and decline at 3.4% per year over the project's life.

The financial outcome for IPP is also insensitive to changes in the load factor to the financial return to the investor follows from the design of the PPA. It was in fact designed so that the investor is almost neutral to decisions by the system operator on how intensely the plant is to be run over time as he tries to minimize the financial costs of generation.

Capacity Payment: The capacity payment component of the sales tariff, assumed to be US\$295,000/MW/Year under the PPA, has a very significant impact on the project. As Table 19.4 shows, setting this component at US\$ 20,000 MW/Year less than what was proposed, will cause a considerable 9.4 million Rupees decline on the value of FNPV. This is equivalent to 7% of the project's investment costs. The observed sensitivity to this variable is due to the fact that the capacity payment represents more than 90% of the IPP's revenue. For the private investor to be able to cover its opportunity costs, the capacity payment should be greater than

US\$294,200MW/Year. The importance of this component is also confirmed by the reported debt service ratios. The lower the amount set by the contract, the more difficult it becomes for the net cash flow of the project to cover the scheduled loan repayment.

Table 19.4: Sensitivity Test of Capacity Payment

Capacity Payment (US\$)	FNPV (m rupees)	ADSCR 2010	ADSCR 2011	ADSCR 2012	LLCR 2010	LLCR 2011	LLCR 2012
265,000	-14.07	1.08	1.27	1.30	1.33	1.37	1.39
275,000	-9.05	1.14	1.33	1.37	1.39	1.44	1.45
285,000	-4.28	1.20	1.38	1.41	1.45	1.50	1.52
295,000	0.37	1.24	1.43	1.47	1.51	1.56	1.58
305,000	5.02	1.28	1.48	1.52	1.57	1.62	1.65
315,000	9.68	1.32	1.53	1.57	1.63	1.68	1.71
325,000	14.33	1.36	1.58	1.62	1.69	1.74	1.78
335,000	18.98	1.40	1.63	1.67	1.75	1.81	1.84

Variable Operating and Maintenance Cost Component: This is another component of the salestariff which accounts for the coverage of operating and maintenance costs except fuel. Its value is expected to be US\$2.91per MWh of the metered electricity sold to the utility. The sensitivity analysis reveals that \$1 downward deviation from the proposedratereduces the FNPV by 2.76 million Rupees. To insure a positive FNPV this component should be set above US\$2.77per MWh, keeping all other parameters constant. The debt ratios are also affected from the changes in this parameter. However, the impact on the overall outcome of the project is much lower than that of thecapacity payment.

Domestic Inflation:The higher the expected rate of inflation in Adukki, the lower is the reported FNPV of the project. If the inflation rate in the future is 2% higher than the assumed 8.9% annual rate, the FNPV declines by 0.71 million Rupees. This means that the negative effect of domestic inflation on real accounts receivable, real cash balance and corporate income tax payment is bigger than the positive effect on real accounts payable. A higher rate of domestic inflation would adversely affect the ADSCR and LLCR ratios as well but not significantly.

Real Interest Rate on Foreign Loan: The real interest rate charged on the U.S. dollar denominated loan appears to be a critical variablefor the IPP. If the interest rate to be charged by the lender is 1% higher than the 6% real rate assumed in the base case, the FNPV of the IPP

becomes -3.19 million Rupees. At a rate higher than 6.10% per annum, the FNPV becomes negative. The importance of this variable is explained by the fact that the share of debt in financing the cost of investment is high at 70% and the loan has a variable interest rate tied to LIBOR. Hence, a small increase in the cost of debt affects the annual debt repayment and consequently the projected net cash flow considerably. A higher real interest rate on the loan will also be reflected in lower debt coverage ratios making it more difficult for the IPP to service its debt obligations.

19.4 Financial Appraisal of Alternative Electricity Generation Technology

AEC, the sole off-taker of the above generated power, is a state owned vertically integrated utility company. Since its main task is to generate and provide electricity to meet the nation's demand for the lowest cost, it has to ensure that the above IPP proposal of a single cycle plant is the most cost effective technology to deliver the required electric energy. AEC is also responsible for distribution of the electricity throughout the country.

19.4.1 Financial Feasibility of the Single Cycle Plant from the AEC's Perspective

When the AEC purchases the electricity generated by the proposed IPP plant, the electricity will be sold to its end users. The average end user price in Adukki is estimated to be 18.5 US¢/kWh.³ This is equivalent to 223.85 Rupees/MWh, net of VAT. For the purpose of the analysis it is assumed that throughout the life of the project, the real tariff rate will remain unchanged while the nominal tariff rate denominated in local currency will be adjusted in line with domestic inflation. However, if the costs of generation from the IPP are higher than the current electricity retail prices (less transmission and distribution costs) then one would expect that the electricity tariff charged to final consumer would be adjusted to produce sufficient additional revenues for the whole electricity system to cover the higher costs.

To evaluate the financial feasibility from the perspective of the AEC, the accounts receivable is assumed to be 15% of total revenue generated by the utility. It is also assumed that 8% of the electricity purchased from the IPP will be lost during transmission and distribution to the end users.⁴ The total cost of transmission and distribution is estimated to be 95 Rupees/MWh.

³This tariff is estimated as a weighted average of the tariffs charged to different types of consumers.

⁴Transmission losses account for 3%. The distribution losses are assumed to account for the remaining 5%.

Since the utility is responsible for providing the amount of fuel required for the IPP's operation, the cost of LCO becomes an important element for the AEC. In the base case the cost of LCO is assumed to be US\$ 367 per ton or an equivalent of US\$ 49 per barrel. Moreover, the accounts payable by the AEC to the IPP is predicted to be 8% of the total purchases from IPP. The accounts payable owed to others are estimated to be 15% of fuel cost whereas the cash balance is 10% of the total operating cost incurred by the utility. The real rate of return targeted by the utility is 10%. The financial analysis from the perspective of the utility is based on the estimation of incremental financial cash inflows and incremental cash outflows of this investment initiative. This is under the assumption that the utility will need the additional electric energy supply to meet the future demand for electricity. Therefore, the incremental financial benefits (from the utility's perspective) will be measured by the additional revenue obtained from selling to its costumers the electricity generated by the additional capacity of the IPP. The incremental financial cost is measured by the extra cost incurred in order to obtain the electricity from the IPP. Thus, the outflows include the PPA revenue paid to the IPP, fuel purchases delivered to the IPP, transmission and distribution costs, changes in accounts payable and changes in cash balances. The overall incremental impact on the utility is determined by the difference between the two.

From the perspective of the AEC, the viability of this capacity expansion option depends on whether the amount of revenue collected from the sale of electricity is big enough to cover the expenses of obtaining this electricity from the IPP. The resulting net cash flow projections for the utility over the life of the project are presented in Table 19.5. One can see that the discounted value of net financial cash flows over the life of the project is -257 million Rupees, using a 10% real discount rate for equity.

Given the assumptions made, it is not financially attractive for the utility to expand its electricity generation capacity by making such an arrangement for an IPP to build and operate a single cycle electricity generation plant at the current rate of tariffs charged for the additional electricity sold from this generation plant. In order to recover the full cost of this new plant AEC must raise the electricity rates charged to some or all of its customers to recover the higher than average generation costs of either of the two alternative plants under consideration.

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**Table 19.5: Financial Cash Flow Statement from the Utility's (AEC) Perspective when the IPP Implements a Single Cycle Plant
(million Rupees in 2008 prices)**

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2026	2030
INFLOWS																
Sales of Electricity to End Users – peak	79.05	77.08	75.15	73.27	71.44	69.65	67.91	66.21	64.56	62.94	61.37	59.84	58.34	56.88	52.72	0.00
Sales of Electricity to End Users – off peak	79.05	71.82	65.08	58.80	52.94	47.49	42.41	37.69	33.29	29.21	25.42	21.90	18.64	15.62	7.84	0.00
Change in Accounts Receivable – peak	-11.86	-0.67	-0.66	-0.64	-0.62	-0.61	-0.59	-0.58	-0.56	-0.55	-0.54	-0.52	-0.51	-0.50	-0.46	6.73
Change in Accounts Receivable – off peak	-11.86	0.11	0.13	0.14	0.16	0.17	0.18	0.19	0.20	0.20	0.21	0.22	0.22	0.22	0.23	0.24
Total Inflows	134.39	148.34	139.71	131.57	123.92	116.70	109.91	103.51	97.49	91.81	86.47	81.43	76.69	72.23	60.33	6.97
OUTFLOWS																
PPA Revenue paid to the IPP	42.53	41.40	40.30	39.23	38.19	37.18	36.20	35.25	34.33	33.44	32.57	31.72	30.90	30.10	27.84	0.00
Transmission and Distribution Cost	59.38	55.92	52.67	49.60	46.71	43.99	41.43	39.02	36.75	34.61	32.60	30.70	28.91	27.23	22.74	0.00
Fuel Purchases delivered to the IPP	76.97	72.64	68.57	64.73	61.11	57.69	54.47	51.44	48.57	45.88	43.33	40.93	38.67	36.53	30.83	0.00
Change in Accounts Payable with the IPP	-3.40	-0.19	-0.18	-0.18	-0.17	-0.17	-0.16	-0.16	-0.16	-0.15	-0.15	-0.15	-0.14	-0.14	-0.13	1.89
Change in Accounts Payable with Others	-11.54	-0.30	-0.28	-0.26	-0.25	-0.24	-0.22	-0.21	-0.20	-0.19	-0.18	-0.17	-0.16	-0.15	-0.13	3.59
Change in Desired Cash Balance	17.89	0.57	0.55	0.52	0.50	0.48	0.46	0.44	0.42	0.40	0.39	0.37	0.36	0.34	0.30	-6.50
Net VAT Liability	13.30	12.37	11.50	10.68	9.92	9.20	8.53	7.90	7.31	6.76	6.24	5.75	5.30	4.88	3.76	0.00
Total Outflows	195.11	182.42	173.11	164.32	156.00	148.14	140.71	133.68	127.03	120.74	114.79	109.16	103.83	98.79	85.22	-1.02
NET CASHFLOW	-60.72	-34.08	-33.40	-32.74	-32.09	-31.44	-30.80	-30.17	-29.54	-28.93	-28.32	-27.73	-27.14	-	-	7.99
FNPV @10%	-257.3													26.56	24.89	

19.4.2 Financial Feasibility of a Combined Cycle Plant from the AEC's Perspective

The combined cycle plant is an alternative technology for expanding the electricity generation capacity of the system. In a combined cycle power plant there is a gas turbine, which generates electricity in the same way for the single cycle plant, and a steam turbine, which uses the heat dissipated from the first cycle to generate additional electricity. This increases the energy transformation efficiency of the combined cycle plant to 60%⁵ as compared to 32% in the case of the single cycle plant. Another important difference between the two technologies is that the capital cost of a combined cycle is on average 40% higher than that of a single cycle power plant with the same generation capacity.⁶ In this case the combined cycle plant used for comparison purposes will be made up of 84 MW of gas turbines plus 42 MW of thermal generation. In total it will have exactly the same generation capacity of 126 MW as was the case of the single cycle plant.⁷

To facilitate the analysis, the assumptions and parameters of the combined cycle power plant are assumed to be the same as those of the single cycle plant described above except for the following key parameters:

- The investment cost is assumed to be 40% higher than the single cycle alternative. Table 19.6 presents the estimated investment costs of the combined cycle plant by component.
- The estimated fuel efficiency is 60%. This causes the amount of fuel requirement to be lower for the combined cycle power plant.⁸
- Due to higher capital costs, the PPA agreement would imply that the capacity payment component would increase to US\$ 377,200/MW/Year, net of VAT. The other two components of the payments to the independent power producer under the PPA are assumed to be the same as for the single cycle plant option.

⁵Information obtained from http://www.gepower.com/prod_serv/products/gas_turbines_cc/en/h_system/index.htm

⁶Boyce P., M., "Handbook for Cogeneration and Combined Cycle Power Plants", American Society of Mechanical Engineers, (2001). See also Poullikkas, A., "Parametric Study for the Penetration of Combined Cycle Technologies into Cyprus Power System", *Applied Thermal Engineering*, (2004).

⁷While it would lower average cost to have two gas turbines and one steam generator with a larger total capacity, for the purposes of this analysis we have made the total capacity exactly the same for the two alternative generation configurations.

⁸Combined Cycle power plants are those that have both gas and steam turbines supplying power to the network. The plants employ more than one thermodynamic cycle in which a gas turbine generator generates electricity and the waste heat is used to make steam to generate additional electricity through a steam turbine. As a result, the combined cycle power plants enhance the efficiency of electricity generation.

The other assumptions and parameters for the utility are the same as described in the previous section.

**Table 19.6: Combined Cycle Power Plant Investment Costs by Component
(million US\$ in 2008 Prices)**

	2008	2009	Total
Land	0.70	0	0.70
EPC & Engineering			
Initial Operating Tools & Mobilization	3.71	2.91	6.62
GT Turbine & Related Costs	30.64	24.07	54.71
Total EPC Contract (excluding VAT)	40.59	31.89	72.48
Other Costs	5.55	4.36	9.91
Sub-Total	80.49	63.24	143.72
Development Costs (excluding VAT)	11.23	8.82	20.05
Financing Costs	12.94	10.16	23.10
Total Investment Cost	105.35	82.22	187.57

The financial appraisal of the utility in the case when the IPP implements a combined cycle power plant is conducted in the same manner as for the single cycle IPP. The cash inflows from the sale of the project's electricity are expected to be identical since the net energy generation delivered to the AEC is collaborated to be the same in both cases. This is because the net energy generation is determined by technical factors such as the maximum available capacity, degradation factor, average availability factor, auxiliary consumption and plant load factor that are the same for both plants. As specified earlier, the price of electricity charged to the consumers is 223.85 Rupees/MWh, net of VAT. The cash outflows, however, that are associated with the alternative technologies are different.

The financial NPV of using the discount rate for utility of 10% real is -123.4 million Rupees. This means that the incremental financial benefits realized by the utility during the project's life with constant real electricity tariffs are not sufficient to cover its incremental costs. The utility, although losing financially would be better off by 133.9 million Rupees over the project's life with the combined cycle technology as compared to building and operating a single cycle plant. This estimate is based on same assumptions and parameter values as used for the implementation of the single cycle power plant.

19.4.3 Financial Investment in Alternative Technologies from the Utility Perspective

It is important to identify the main differences in costs between the two technologies that make the utility better off if it purchases electricity from an IPP using a combined cycle plant instead of the single cycle plant.

The specific features of these two technologies affect the expenditures of the utility in two aspects. On one hand, a more capital expensive combined cycle plant requires a capacity payment, which is assumed to be almost 28% higher as compared to the equivalent component in the PPA agreement with the single cycle plant. On the other hand, a higher energy transformation efficiency achieved by the combined cycle lowers the amount of fuel requirement for this plant to operate. In other words, the projected PPA payment by AEC to the combined cycle IPP is expected to be higher as compared to the single cycle IPP while the projected expense on fuel purchases delivered to the combined cycle plant is lower.

Table 19.7 presents the difference in the level of expenditures (PPA payment and fuel purchases delivered to the IPP) incurred by the utility when the IPP builds a combined cycle less the expenditures of the utility when the IPP builds a single cycle plant. The divergence in the amount of PPA payments and fuel purchases throughout the life of the project is estimated at different plant load factors and fuel prices simultaneously. To make these expenditures comparable, their present value is calculated, using the 10% real rate of return required by the utility as the discount rate.

Table 19.7: Expenditure Savings from Choosing a Combined Cycle Plant rather than a Single Cycle Plant (PV@10%) (million Rupees in 2008 prices)

		Light Crude Oil Price(US\$/barrel)								
		30	31	45	49	55	59	69	79	89
Initial Plant Load Factor	10%	-46.04	-45.12	-32.94	-29.57	-24.24	-20.76	-12.06	-3.36	5.34
	20%	-28.94	-27.41	-7.25	-1.68	7.15	12.91	27.31	41.71	56.11
	30%	-11.84	-9.70	18.44	26.21	38.54	46.58	66.68	86.78	106.88
	40%	5.26	8.01	44.13	54.10	69.93	80.25	106.05	131.85	157.65
	50%	17.09	20.27	61.91	73.41	91.66	103.56	133.30	163.05	192.80
	60%	28.48	32.06	79.01	91.98	112.55	125.97	159.51	193.05	226.59
	70%	39.51	43.48	95.59	109.98	132.80	147.69	184.91	222.13	259.34
	80%	50.26	54.61	111.73	127.50	152.53	168.85	209.65	250.45	291.25
	90%	60.77	65.49	127.52	144.65	171.82	189.54	233.84	278.15	322.45
	100%	71.07	76.16	143.00	161.46	190.74	209.83	257.57	305.31	353.05

It appears that the higher the load factor and the price of fuel, the more costly it gets for the utility to obtain the electricity from the single cycle IPP as compared to the combined cycle alternative. When the load factor is high, the amount of fuel required for the plant to operate is greater. At higher fuel prices, this translates into greater fuel expenditures incurred by the utility if a single cycle plant is employed. At an average plant load factor of 80% and fuel price costing US\$ 49 per barrel, the utility would save almost 128 million Rupees if the IPP were to use a combined cycle IPP as compared to the single cycle IPP. This implies that the overall electricity tariff rates charged will need to be higher in order to pay for the higher fuelcosts if the additional electricity obtained by the utility is generated using a single cycle IPP.

We also see from Table 19.7 that if the utility's cost of capital was 10% then for a price of US\$ 49 per barrel of oil the utility should only prefer the single cycle plant if it were going to use it on average 20 percent of the time or approximately 1750 hours per year. If it needed a plant that would operate in the system for more hours per year it would be much better off employing an IPP that was using a combined cycle generation plant. With an US\$ 79 per barrel price of oil the single cycle would only be attractive if it was only going to be used 10 percent of the time or only about 876 hours a year. This is completely unrealistic for any new generation plant being introduced into a mature electricity generation system. At an average price of US\$ 79 per barrel and an 80% load factor the selection of the single cycle plant will cost the public utility an extra amount over the lifetime of the project equal to \$ 250 million (an present value terms using 10% discount rate) or 1.9 times the entire capital cost of the single cycle plant.

The present values in Table 19.7 were estimated using a real financial discount rate of 10 percent. This rate is likely to be too high considering that the relevant discount rate should reflect the real weighted cost of capital. For a public utility a real rate of 6% would more closely reflect AEC's real weighted average cost of capital. Table 19.8 reports the present values of the cost differences between the combined versus the single cycle technology, using 6% as the discount rate.

The current plans are to use this plant at a load factor of 80%. With this load factor and an average real cost of fuel of US\$49 per barrel we find that the combined cycle has a present value of costs that is 365 million Rupees lower than that of the single cycle plant. At an average price of fuel of US\$79 per barrel the cost advantage of the combined cycle plant is a present value as

of 2008 of 572 million Rupees or more than 4.3 times the entire capital cost of the single cycle generation plant.

In this case even if the price of oil was as low as US\$ 30 per barrel it would never be financially worthwhile even if the plant was being utilized as little as 10% of the time.

Table 19.8: Expenditure Savings from Choosing a Combined Cycle Plant rather than a Single Cycle Plant (PV@6%) (million Rupees in 2008 prices)

		Light Crude Oil Price(US\$/barrel)								
		30	31	45	49	55	59	69	79	89
Initial Plant Load Factor	10%	70.74	72.38	93.99	99.96	109.43	115.60	131.03	146.47	161.90
	20%	101.88	104.61	140.37	150.25	165.92	176.14	201.68	227.23	252.78
	30%	133.03	136.83	186.75	200.54	222.41	236.68	272.34	308.00	343.65
	40%	164.17	169.05	233.13	250.83	278.91	297.22	342.99	388.76	434.53
	50%	183.01	188.54	261.23	281.30	313.14	333.91	385.82	437.74	489.66
	60%	200.93	207.09	287.97	310.30	345.73	368.84	426.60	484.37	542.13
	70%	218.16	224.92	313.67	338.18	377.05	402.41	465.80	529.19	592.58
	80%	234.83	242.17	338.53	365.15	407.36	434.89	503.73	572.56	641.39
	90%	251.03	258.94	362.71	391.37	436.83	466.48	540.60	614.73	688.85
	100%	266.84	275.30	386.30	416.96	465.59	497.30	576.59	655.88	735.16

To sum up, the financial appraisal of the utility under different scenarios discussed above indicates that the utility would be better off purchasing electricity from an IPP using a combined cycle plant, since this technology is much more fuel efficient and hence less costly at high load factors. The fuel consumption at high load factors has a big impact on the utility cash flow projections since it is subsidized by the utility. Hence from the perspective of the public utility, the combined cycle IPP is a better private partner from which to purchase electricity. However, under the provision that the utility supplies fuel for free to the IPP, the private investor would prefer to implement the single cycle plant since it requires less capital, hence easier to finance.

19.4.4 Financial Sensitivity Analysis from the AEC's Perspective

A sensitivity analysis is carried out to assess the financial implication for the utility to changes in key parameters employed in the model. Ultimately these financial impacts on the electric utility will be borne by financial consumers as the utility attempts to recover its costs.

Plant Load Factor: The load factor measures the average output as compared to the maximum capacity that the plant could theoretically generate during the year. The assumption made in our model is that the load factor is expected to start at 80% and then to decline by 3.4% per year. The results of the sensitivity analysis for the plant load factor are shown in Table 19.9. A higher plant load factor causes the financial NPV of the AEC to become less negative for both the single and the combined cycle plants. The FNPV of the utility when the single cycle technology is employed by the IPP is not very sensitive to increases in the plant load factor. This is not the case, however, when a combined cycle plant is implemented by the IPP. Increasing the load factor of the combined cycle plant by 10% improves the FNPV of the AEC by almost 18 million Rupees (compared to 1 million Rupees in case of the single cycle). This is due to the fact that the increase in financial revenues from increased sales is greater than the additional fuel costs hence the combined cycle plant makes a greater contribution to the financial NPV if more generation (with higher load factor) takes place. The amount of fuel savings resulting from the combined cycle alternative is shown in the last column of Table 19.9.

**Table 19.9: Sensitivity Test of Plant Load Factor
(million Rupees in 2008 prices)**

Load Factor	FNPV-SC	FNPV-CC	FNPV-CC Less FNPV-SC
17%	-263.89	-266.39	-2.50
70%	-258.13	-141.59	116.53
75%	-257.70	-132.43	125.28
80%	-257.29	-123.37	133.92
85%	-256.87	-114.41	142.46
90%	-256.46	-105.55	150.92
95%	-256.06	-96.77	159.29
100%	-255.66	-88.07	167.59

Fuel Price: The price of fuel plays an important role on the financial NPV of the AEC as the results of the sensitivity test show in Table 19.10. An increase in the price of fuel raises considerably the utility's operating expenditure resulting in a negative impact on its net cash flow. In particular, the FNPV of the utility when it uses the electricity generated by the single cycle IPP is affected negatively more by a change in a fuel prices as compared to the combined cycle technology. If the price of light crude oil increases from US\$49 per barrel to US\$52 per barrel, the FNPV decreases by almost 27 million Rupees for the single cycle plant as compared to 14 million Rupees for a combined cycle plant. This means that, keeping everything else the same, the FNPV of the utility is expected to be twice as sensitive to fluctuations in the price of

fuel if the private investor builds the proposed single cycle plant. In either case, however, fuel price changes will ultimately pass through to final users.

Table 19.10: Sensitivity Test of Fuel Price
(million Rupees in 2008 prices)

Crude Oil Price (US\$/barrel)	FNPV-SC	FNPV-CC	FNPV-CC Less FNPV-SC
41	-188.50	-86.68	101.82
44	-214.51	-100.56	113.95
46	-231.85	-109.80	122.05
49	-257.29	-123.37	133.92
52	-283.88	-137.55	146.33
54	-301.22	-146.80	154.42
71	-327.23	-160.67	166.56

Real Exchange Rate: The real exchange rate is a crucial parameter for the electric utility as Table 19.11 demonstrates. Devaluation of the Adukkian Rupee in relation to the U.S. dollar worsens the FNPV of the utility, no matter the technology choice. Nevertheless, the magnitude of the impact of the real exchange rate movement on the utility's FNPV differs between the two technologies. A change in the real exchange rate from 1.21 Rupees to 1.31 Rupees per U.S. dollar causes the FNPV of the AEC to decrease by almost 45 million Rupees when the combined cycle technology is employed. The same devaluation causes a 56 million Rupees decline in FNPV if a single cycle plant is built. The devaluation of the domestic currency affects the single cycle plant more since it requires more fuel to operate. Given that the fuel is imported and priced in the U.S. dollars, the impact of the currency devaluation on the FNPV of the utility is substantial.

Table 19.11: Sensitivity Test of Real Exchange Rate
(million Rupees in 2008 prices)

Real Exchange Rate (Rupees/US\$)	FNPV-SC	FNPV-CC	FNPV-CC Less FNPV-SC
0.90	-85.01	14.60	99.61
1.01	-146.14	-34.36	111.78
1.11	-201.71	-78.86	122.85
1.21	-257.29	-123.37	133.92
1.31	-312.86	-167.87	144.98
1.41	-368.43	-212.38	156.05
1.51	-424.01	-256.89	167.12
1.61	-479.58	-301.39	178.19

19.4.5 Estimation of the Levelized Financial Costs of IPP-Single Cycle and IPP-Combined Cycle Plant

Instead of estimating the financial NPV from AEC's point of view for the two different types of plants one could measure the financial cost effectiveness of the two plants by estimating their financial levelized cost of generation. This is carried out by estimating the present value of the full lifecycle costs associated with each of the alternative plants and divide these estimated total financial costs by the present value of the amount of electric energy generated by the corresponding plant. The results of this analysis are presented in Table 19.12. The difference between the levelized financial costs is 0.034 Rupees per kWh or US\$0.028 per kWh.

Table 19.12: Levelized Financial Cost of Energy in the Base Case Scenario

Category	Single Cycle Plant	Combined Cycle Plant	Cost: CC Less SC
PV of Financial Cost (million Rupees):			
Investment Costs	164.46	230.24	65.78
O&M Costs	76.16	76.16	0
Fuel purchased and delivered to the IPP	377.93	201.56	-176.37
Total	618.55	507.97	-110.58
PV of Net Energy Generated (MWhs)	3,297,471	3,297,471	-
Leverlized cost of energy:			
Cost expressed in Rupees/kWh	0.188	0.154	-0.034
Cost expressed in US\$/kWh	0.154	0.127	-0.028

In this case either of the two technologies will improve the reliability of electric energy supply, however, the single cycle technology is for more expensive for the public utility.

19.5 Economic Appraisal

The economic appraisal evaluates the impacts of the project on the entire society and determines whether the project contributes to the country's wealth and the economic welfare of its residents. In the context of applying the integrated appraisal framework, the economic evaluation is directly linked to the consolidated financial cash flow statement of the project. The economic analysis is structured to be in full consistency with the financial analysis and is based on the project's financial values and parameters.

These financial values are converted into their respective economic values by making a series of adjustments. The relationship between the financial and economic value of a particular good or service is called a Commodity Specific Conversion Factor (CSCF), which is calculated as the

ratio of the economic value to the financial price. Once the conversion factors are computed, they are multiplied by the respective financial values in order to obtain the corresponding economic values.

The financial analysis from the perspective of the utility concluded that the technology choice for this power project is very important. It was estimated that if the plant load factor is higher than 35% when the price of fuel exceeds US\$31 per barrel, the present value of total costs incurred by the utility discounted at 10% real for the single cycle plant surpasses that of the combined cycle. As well, if the price of fuel were US\$49 per barrel and if the load factor is above 21% the single cycle plant would be more expensive than the combined cycle plant. The first step in the economic appraisal for this project is to identify the technology that will expand the electricity supply at the lowest cost from the economic perspective. This will be achieved by identifying the technology that results in the lowest resource cost of energy for generating the same amount of power.

19.5.1 Economic Valuation of Project's Costs

The economic costs of the project are the incremental costs of the country's resources used in the project. Apart from the financial values projected in the consolidated financial statement, a number of economic assumptions and parameters used in the analysis must be made in order to estimate the economic costs for generating additional electricity by the project.

National Parameters

- The economic opportunity cost of capital (EOCK) for Adukkii is estimated to be 12% real.⁹
- The foreign exchange premium (FEP) on tradable goods is estimated to be 8%.
- The shadow price of non-tradable outlays (SPNTO) is estimated 1% higher than its market price.

Economic Value of Tradable Goods and Services

The financial prices of tradable goods are determined in the international markets and their values may be affected by import duties, value added taxes, excise taxes, export taxes and

⁹The methodology of measuring this parameter is outlined in Chapter 8. See, for example, C.Y. Kuo, G.P. Jenkins, and M.B. Mphahlele, "The Economic Opportunity Cost of Capital in South Africa", *South African Journal of Economics*, (September 2003).

subsidies. The economic values of these items will be free of these distortions but they must account for the foreign exchange premium. The tradable inputs to the project and their related taxes are described below.

- Imported capital items including the initial operating tools and mobilization, gas turbine and its related costs as well as other costs are not subject to any import duty or VAT.
- The light crude oil is imported and is subject to a 5% import duty levied on the CIF price. It is exempted from VAT.
- Major maintenance materials such as Long Term Service Agreements, both its fixed and variable components, are subject to an average tariff of 12%. These costs are not subject to VAT.
- Operation and maintenance materials are subject to 20% import duty. The 13% VAT is not applied on these items.
- Tradable services such as advisory and consulting fees are taxed at 13% VAT.

Economic Value of Non-Tradable Goods

Non-tradable goods are those not traded internationally. Their economic value is determined by their demand price, supply price, and the various distortions associated with this market as well as a series of intermediate inputs required to produce the good in question. The methodology is outlined in Chapter 11. The non-tradable goods and services used in the project are listed below.

- Infrastructure and civil works are the non-tradable items covered by the EPC contract.
- Non-tradable inputs of the infrastructure and civil works are sourced domestically and are subject to the 13% VAT when purchased.

Labor

- The economic opportunity cost of labor (EOCL) is estimated using the supply price approach discussed in Chapter 12. This approach starts with the market wage paid by the project in the project region and makes all the necessary adjustments with regard to personal income taxes as well as social security contributions to arrive at the EOCL.
- The labor sourced domestically is composed of 90% skilled and 10% unskilled workers. The skilled labor is subject to 25% personal income tax whereas the unskilled category to 15%. The corresponding social security contributions are estimated to be 17.5% and 10%, respectively. It is estimated that in the absence of this project, skilled and unskilled labor would have spent 90% and 50% of their time, respectively, employed elsewhere.

- Foreign engineers are also employed by the project to work on the activities covered by the EPC contract. The estimation of the EOCL in the case of foreign labor is similar to the approach used for domestic labor with the exception that it takes into account the foreign exchange premium forgone on the remittances of net income earned and the amount of VAT collected from their consumption in Adukki. The share of the income repatriated is estimated to be 65%. The social security contributions and income tax are assumed to be 15% and 25%, respectively.
- The project wages for skilled and unskilled labor are expected to be R 2,000 higher per year than the minimum wage gross of taxes that would attract sufficient workers to this project.

Working Capital

- The conversion factor for changes in accounts payable of the utility as well as changes in the desired cash balance is taken as 1.
- The change in utility's accounts payable with other suppliers has the same conversion factor as fuel.

Using the information presented above a series of CSCF for the project outlays are estimated and summarized in Table 19.13.

Table 19.13: Summary of Specific Conversion Factors

Categories	CSCF
Investment Costs	
Land	1.000
Initial Operating Tools & Mobilization	1.074, Same as imported capital items
GT Turbine & Related costs	1.074, Same as imported capital items
Total EPC Contract	0.683 Average (infrastructures & civil works and foreign labor)
Other Costs	1.074, Same as imported capital items
Development Costs	0.937, Average tradable and non-tradable services
Financing Costs	1.000
Operating \$ Maintenance Fixed Costs	
General & Administration	0.810, Same as skilled labor
Long Term Service Agreement & Others	0.963, Same as major maintenance conversion factor
Operating \$ Maintenance Variable Costs	
Water	0.918, Same as non-tradable good
Chemicals & Lubrication Oil	1.029, Same as fuel conversion factor
Transmission and Distribution Cost	1.074, Same as imported capital items
Fuel Purchases delivered to the IPP	1.029

Change in Accounts Payable for IPP	0.934, Average of CSCFs for Major O&M Materials, Tradable Services (Advisory & Consulting Fees), Tradable Good (Water) & Services (Development Fees)
Change in Accounts Payable for Utility (fuel purchases)	1.029
Change in Desired Cash Balance for IPP	1.000
Change in Desired Cash Balance for Utility	1.000
Labor	
Unskilled	0.625
Skilled	0.810
Foreign	0.604

19.5.2 Economic Evaluation of Selecting an IPP with Alternative Technologies

The economic analysis begins with the undertaking of an economic cost-effectiveness analysis to compare the levelized energy cost of the alternative electricity generation options when they provide the same amount of electricity. The levelized energy cost methodology is usually applied to compare two or more technologies that have different characteristics. In the current case, the two technologies differ in terms of investment costs and fuel usage. The levelized cost is computed as the present value of the total economic costs (including investment cost, operating costs and fuel expenditure) incurred over the project's life divided by the present value of the net electricity generation sent out from the plant during the same period of time. This represents the costs that ultimately will have to be borne by consumers or financed by the state owned utility.

Since the net electricity generated by the combined cycle plant in this case is exactly the same as the single cycle plant over the same period of time, the first step of the economic appraisal for the two alternative technologies is carried out by comparing all the costs expressed in the present value of the resource costs discounted by the real economic cost of capital that is 12% in Adukki. These results are displayed in the upper part of Table 19.14 for the two alternative technologies. The incremental costs (or cost savings) of the combined cycle plant as compared to that of the single cycle plant are then shown in lower part of the table. Comparison of these results shows that 120.85 million Rupees (in 2008 prices) could be saved by investing in a combined cycle instead of a single cycle plant, using our assumptions for the base case scenario.

CHAPTER 19:

**Table 19.14 : Economic Resource Costs for the Alternative Technologies
(million Rupees in 2008 prices)**

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2026	2030
Combined Cycle Plant																		
Investment Costs																		
Land	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.85
Other Assets	120.31	94.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-42.97
Operating & Maintenance Costs																		
Labor	0.00	0.00	2.11	2.18	2.24	2.31	2.38	2.45	2.52	2.60	2.68	2.76	2.84	2.93	3.01	3.10	3.39	0.00
Other Fixed O&M Costs	0.00	0.00	6.79	6.80	6.82	6.84	6.85	6.87	6.88	6.90	6.92	6.93	6.95	6.97	6.98	7.00	7.06	0.00
Fuel Purchases delivered to the IPP	0.00	0.00	42.22	39.85	37.61	35.51	33.52	31.65	29.88	28.22	26.65	25.17	23.77	22.45	21.21	20.04	16.91	14.29
Other Variable O&M Costs	0.00	0.00	1.08	1.04	1.00	0.97	0.94	0.91	0.88	0.85	0.82	0.80	0.78	0.76	0.74	0.72	0.67	0.62
Transmission and Distribution Cost	0.00	0.00	63.79	60.07	56.58	53.28	50.18	47.26	44.51	41.92	39.48	37.18	35.01	32.98	31.06	29.25	24.43	20.41
Change in Working Capital	0.00	0.00	8.98	0.38	0.37	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.28	0.27	0.26	0.24	0.22
Total Costs	121.16	94.53	124.97	110.32	104.62	99.26	94.21	89.46	85.00	80.79	76.84	73.13	69.64	66.36	63.27	60.37	52.70	-47.88
PV @ 12%	796.50																	
Single Cycle Plant																		
Investment Costs																		
Land	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.61
Other Assets	85.94	67.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-30.69
Operating & Maintenance Costs																		
Labor	0.00	0.00	2.11	2.18	2.24	2.31	2.38	2.45	2.52	2.60	2.68	2.76	2.84	2.93	3.01	3.10	3.39	0.00
Other Fixed O&M Costs	0.00	0.00	6.79	6.80	6.82	6.84	6.85	6.87	6.88	6.89	6.92	6.93	6.95	6.97	6.98	7.00	7.06	0.00
Fuel Purchases delivered to the IPP	0.00	0.00	79.16	74.72	70.53	66.58	62.85	59.34	56.03	52.91	49.96	47.19	44.57	42.10	39.77	37.58	31.71	0.00
Other Variable O&M Costs	0.00	0.00	1.08	1.04	1.00	0.97	0.94	0.91	0.88	0.85	0.82	0.80	0.78	0.76	0.74	0.72	0.67	0.00
Transmission and Distribution Cost	0.00	0.00	63.79	60.07	56.58	53.28	50.18	47.26	44.51	41.92	39.48	37.18	35.01	32.98	31.06	29.25	24.43	0.00
Change in Working Capital	0.00	0.00	5.94	0.27	0.26	0.25	0.24	0.24	0.23	0.22	0.21	0.21	0.21	0.20	0.19	0.19	0.18	-2.84
Total Costs	86.54	67.52	158.87	145.08	137.43	130.22	123.44	117.06	110.05	105.39	100.07	95.07	90.36	85.93	81.76	77.84	67.43	-34.14
PV @ 12%	917.35																	
Cost Savings from Choosing a Combined Rather Than a Single Cycle Plant																		
Investment Costs	-34.61	-27.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.52
Fuel Purchases delivered to the IPP	0.00	0.00	36.94	34.87	32.91	31.07	29.33	27.69	26.15	24.69	23.32	22.02	20.80	19.65	18.56	17.54	14.80	0.00
Change in Working Capital	0.00	0.00	-3.04	-0.11	-0.11	-0.10	-0.10	-0.10	-0.09	-0.09	-0.09	-0.08	-0.08	-0.08	-0.07	-0.07	-0.06	1.22
Total	-34.61	-27.01	33.90	34.76	32.81	30.97	29.23	27.60	26.05	24.60	23.23	21.94	20.72	19.57	18.49	17.46	14.73	13.74
PV @ 12%	120.85																	

The above results for the base case scenario assume that both plants will begin with an 80% load factor and that the price of fuel is US\$ 49 per barrel. Using these parameters, the estimated levelized energy cost as shown in Table 19.15 is 0.146 Rupees per kWh for the combined cycle plant, which is lower than 0.183 Rupees per kWh for the single cycle. This is an equivalent to US\$ 0.121 per kWh and US\$ 0.152 per kWh, respectively. The difference between the levelized energy costs of the two technologies amounts to 0.037 Rupees (US\$ 0.031) per kWh. This difference translates into a 16.5% increase in the retail electricity rates that the utility would have to charge to consumers on this quantity of electricity in order to cover the additional costs that would otherwise not be necessary.¹⁰

Table 19.15 :Levelized Economic Cost of Energy for the Base Case Scenario

Category	Combined Cycle Plant	Single Cycle Plant	Cost Savings from Choosing a Combined Cycle versus a Single Cycle Plant
PV of Economic Cost* (million Rupees):			
Investment Costs	205.57	146.83	-58.74
O&M Costs	68.95	68.95	0
Fuel purchased and delivered to the IPP	207.32	388.72	181.40
Total	481.84	604.51	122.67
PV of Net Energy Generated (MWhs)	3,297,471	3,297,471	-
Levelized cost of energy:			
Cost expressed in Rupees/kWh	0.146	0.183	0.037
Cost expressed in US\$/kWh	0.121	0.152	0.031

Note: *The economic costs shown in this table slightly differ from Table 19.14 in which it includes the transmission and distribution costs as well as changes in working capital.

As was pointed out earlier in the financial analysis, the higher the load factor and the higher is the price of fuel, the more costly it is for the utility to obtain the electricity from the single cycle plant as compared to the combined cycle plant. Our next step is to make a similar comparison from the economic (as distinct from the financial) point of view.

Table 19.16 shows the present value of the differences in total economic costs (fuel plus capital) over the life of the project if a combined cycle plant is selected rather than a single cycle plant. Table 19.17 presents the results expressed differently by measuring levelized economic cost of energy over the life of the project. They are both simulated for different combinations of plant load

¹⁰The utility would likely build these costs into its overall rate structure so that a higher tariff would be charged on the consumption of all customers. Hence, the increase in the average rate would be substantially less than 16.5 percent.

factors and fuel prices. For instance, implementing the combined cycle plant for the base case scenario (fuel cost at \$49 per barrel and a load factor of 80%) will save 120.85 million Rupees in 2008 prices over its lifetime. Equivalently, it has a levelized cost of generation that is 0.037 Rupees/kWh cheaper as compared to the single cycle plant.

Table 19.16: Resource Cost Savings from Selecting a Combined Cycle versus a Single Cycle Plant (million Rupees in 2008 prices)

		Light Crude Oil Price (US\$/barrel)								
		30	31	45	49	55	59	69	79	89
Initial Plant Load Factor	10%	-35.85	-35.24	-24.42	-21.02	-16.69	-12.88	-5.25	2.37	10.10
	20%	-20.80	-19.78	-1.87	3.76	10.92	17.23	29.85	42.47	55.26
	30%	-5.75	-4.32	20.68	28.54	38.53	47.34	64.96	82.57	100.43
	40%	9.31	11.14	43.23	53.31	66.14	77.45	100.06	122.67	145.59
	50%	20.07	22.19	59.35	71.02	85.88	98.97	125.16	151.34	177.88
	60%	30.45	32.85	74.88	88.10	104.91	119.72	149.35	178.98	209.00
	70%	40.52	43.19	89.97	104.67	123.39	139.87	172.84	205.81	239.22
	80%	50.35	53.28	104.69	120.85	141.41	159.53	195.76	231.99	268.71
	90%	59.97	63.17	119.11	136.69	159.06	178.78	218.20	257.62	297.58
	100%	69.42	72.87	133.26	152.24	176.40	197.68	240.24	282.79	325.93

Note: The resource cost savings from choosing the combined cycle versus the single cycle plant for the base case (120.85 million Rupees) is slightly different from that presented in Table 19.15 (122.67 million Rupees) because the former takes into account changes in working capital where the latter does not.

Table 19.17: Cost Saving per (Levelized) kWh from Selecting a Combined Cycle versus a Single Cycle Plant (Rupees/kWh in 2008 prices)

		Light Crude Oil Price (US\$/barrel)								
		30	31	45	49	55	59	69	79	89
Initial Plant Load Factor	10%	-0.072	-0.071	-0.049	-0.042	-0.033	-0.025	-0.009	0.006	0.022
	20%	-0.021	-0.020	-0.001	0.005	0.012	0.018	0.031	0.044	0.058
	30%	-0.003	-0.003	0.015	0.020	0.027	0.033	0.045	0.057	0.069
	40%	0.005	0.006	0.023	0.028	0.034	0.040	0.052	0.063	0.075
	50%	0.009	0.010	0.026	0.031	0.038	0.044	0.055	0.066	0.078
	60%	0.012	0.013	0.029	0.034	0.040	0.046	0.057	0.068	0.080
	70%	0.014	0.015	0.031	0.036	0.042	0.048	0.059	0.070	0.081
	80%	0.016	0.017	0.032	0.037	0.043	0.049	0.060	0.071	0.082
	90%	0.017	0.018	0.033	0.038	0.045	0.050	0.061	0.072	0.083
	100%	0.018	0.019	0.035	0.039	0.046	0.051	0.062	0.073	0.084

The results are similar to the conclusions reached in the financial analysis when the utility's expenditures are discounted at 10%. That is, if the price of crude oil is higher than US\$ 30 per barrel it would be economically worthwhile to implement the combined cycle plant so long as the initial load factor is greater than 40%. If the price of oil is higher than US\$ 45, the combined cycle plant should be chosen over the single cycle plant even if the load factor is as low as 20%. These results imply a very substantial negative impact on consumers if a single cycle plant is built. Furthermore, as it involves the waste of fossil fuel the implementation of a single cycle generation plant creates more environmental damage than would otherwise be the case.

Because of the lower capital outlays required from the private investors if they implement a single cycle generation plant and because the fuel costs are borne by the public sector off-taker of the electricity, the private investors often prefer to employ single cycle gas turbine technology. Furthermore, as the capital costs are explicit in the PPA, and the fuel costs are not, it might appear to decision makers that the single cycle generation plant is less costly, while in fact it is much more costly when the full life cycle costs are taken into account.

In the analysis below it is assumed that these perverse financial incentives have caused decision-makers to select the single cycle (gas turbine) technology for the IPP. The stakeholder implications of such a decision is considered here.

19.6 Stakeholder Impacts

The purpose of the stakeholder analysis is to identify the impacts that the proposed technology has on different interest groups (stakeholders) in the society. Quantification of these impacts is an important part of the stakeholder analysis in order to find out how much each stakeholder would gain or lose as a result of the project implementation. To be able to undertake this analysis, the projected benefits and costs from the financial and economic appraisal are used.

19.6.1 Identification of Stakeholders and Externalities

The stakeholder analysis of the BLEG project is conducted to identify which segments of the society in Adukki benefit and which ones, if any, lose from the implementation of the combined cycle plant instead of the single cycle plant. This representation emphasizes the fact that the proposed technology creates two types of net benefits: financial net benefits, reaped by the parties that have a financial interest in the project; and externalities, which accrue to different segments of the Adukkian society affected by the proposed technology.

To carry out the stakeholder analysis, the following steps are required:

- Firstly, the stakeholder impacts of the project are identified item-by-item, by subtracting the financial cash flow statement from the economic statement of benefits and costs.
- Secondly, the present value of each line item's flow of externalities is calculated over the life of the project,¹¹ using the economic cost of capital in Adukki as the discount rate.
- Finally, the present value of the externalities is allocated to the affected groups in the economy.

The reconciliation between the incremental financial flows of the utility, economic resource flows and distributional impacts of the proposed combined cycle plant as compared to the single cycle plant is demonstrated in Table 19.18. To ensure that the analysis is performed in a consistent way, the present value of the economic cost saving must equal the present value of financial cost saving plus the present value of the difference in externalities. In other words, the combined cycle plant has lower economic costs of 120.85 million Rupees that is comprised of lower financial cost savings of 108.83 million Rupees and positive externalities of 12.02 million Rupees. This is shown in Table 19.18.

¹¹The value of externalities such as import duties, taxes, consumer surplus and producer surplus can be measured by the difference between the financial value and the economic value associated with the distortions of the item in question.

Table 19.18: Present Value of Cost Savings for a Combined Cycle versus a Single Cycle Plant (million Rupees in 2008 prices)

	Financial Cost Savings	Externality Savings	Sum of Financial Cost plus Externality Savings	Total Savings of Economic Cost
Investment Costs				
Land	-0.24	0.02	-0.22	-0.22
Other Assets	-64.38	6.91	-57.48	-57.48
Operating & Maintenance Costs				
Fixed Costs	0	0	0	0
Variable Costs:				
Fuel	176.37	5.04	181.40	181.40
Others	0	0	0	0
Change in Taxes & Working Capital	-2.91	0.05	-2.86	-2.86
Total Costs	108.83	12.02	120.85	120.85

19.6.2 Distributive Impacts

In this case, the difference in the present value of financial costs will ultimately be borne by electricity consumers through higher electricity tariffs. The PPA was designed to compensate the private owner of the plant for differences in financial costs they would incur.

The externalities generated by this type of power project are perceived by the government and electricity consumers. In this case, the combined cycle plant is supplying the same amount of electricity to consumers as the single cycle plant over the life of the project, so the additional benefits to consumers are created by the lower costs of generation rather than increased consumption of electricity. The amount is 108.83 million Rupees. The externality of 12.02 million Rupees represents the additional taxes collected on import duties, corporate income taxes and VAT, corrected for the additional foreign exchange premium associated with differences in the volume of tradable inputs used by the two types of plants.

19.7 Conclusions

The evaluation of this project was carried out using the integrated investment appraisal methodology. The proposed project aimed to expand the electricity generation capacity by 126 MW in order to reduce the recent electricity shortages and outages in Adukki. A single cycle thermal plant had been proposed to be built and operated by an Independent Power Producer. The state utility, AEC, is the only off-taker of the additional electricity generated by this plant and the price paid to the IPP had to be negotiated through a long term Power Purchase Agreement.

The assessment of the financial feasibility of the private sector involvement in power generation is the first step of this analysis. The financial appraisal of this project was not limited to the evaluation of the IPP single cycle plant as a stand-alone project. The financial evaluation is also carried out from the utility's perspective under an alternative combined cycle technology. This appraisal serves the purposes of determining whether the IPP involvement is justified from the perspective of the AEC in which the least costly electricity generation technology must be chosen.

The financial feasibility of the IPP project per se is evaluated from two perspectives, the lender's point of view and the private investor's point of view. With regard to whether the project is able to service its debt obligations, the projected ADSCR ratios are calculated against the 1.3 benchmark set by the lenders. There is some risk in the first year in which the ADSCR is 1.24. However, the LLCR ratios improve gradually throughout the debt service period indicating that the project should be able to generate sufficient cash flow to fulfill its debt service obligations.

From the private investor's point of view, the value for the financial NPV of the single cycle IPP equals 0.37 million Rupees. This means that the private investor is able to generate enough cash over the life of the project to cover the investment cost and earn a rate of return no less than the 13% real cost of capital.

From the perspective of the utility, when the IPP is involved in the expansion of the system by building a single cycle plant, the impact on its financial present value is -257 million Rupees using the 10% real rate of return required by the utility as the discount rate. This means that the discounted value of the additional revenues from the sale of electricity is not able to cover all costs

under the PPA payment as well as the fuel expenditure incurred by the utility for the operation of the single cycle IPP. However, the implementation of an alternative combined cycle plant by the IPP would result a lower negative financial impact of a percent value of -123 million Rupees for the AEC. This means that even though the combined cycle is more expensive in terms of capital expenditures (40% higher than the single cycle plant), the fuel savings due to its higher energy transformation efficiency make the IPP combined cycle plant a better private partner to purchase the electricity from. The results of the financial analysis indicate that the superiority of the combined cycle IPP, in terms of cost savings, is more evident at high plant load factors and high fuel prices. It was estimated that as far as the plant load factor is higher than 20% and the price of fuel exceeds US\$49 per barrel, a combined cycle plant would have a lower present value of total costs incurred for the utility than a single cycle plant.

Even though the combined cycle IPP is more beneficial for the utility, the AEC has given the wrong incentive to the private investor. If the AEC subsidizes the fuel, the private investor would be more interested in investing in a single cycle plant since it requires less capital and thus is easier to finance as compared to the combined cycle technology.

In this chapter, cost effectiveness analysis has been employed to compare the single cycle and the combined cycle technology. The resource cost of the combined cycle plant for the source of electricity generation is lower due to its lower fuel requirement as compared to the single cycle option. A full economic appraisal is then carried out to determine the project's contribution to the country's wealth and the economic welfare of its residents. Expansion of the system by employing the most efficient technology, the combined cycle, is expected to save resource costs equal to 120 million Rupees, using the 12% real economic opportunity cost of capital as the discount rate. This is an indication that the implementation of the combined cycle technology is justified economically.

To sum up, the financial and economic appraisal under different scenarios discussed above indicate conclusively that the utility and the country would be better off if the IPP employs a combined cycle technology rather than a single cycle thermal technology.

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**COST-BENEFIT ANALYSIS FOR INVESTMENT DECISIONS,
CHAPTER 20:**

RESTRUCTURING THE WATER AND SEWER UTILITY IN PANAMA

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ABSTRACT

In the 1980s, investments in Panama's water supply and sanitation sector centered on expanding the system capacity to meet the growing demand. However, since the facilities were constructed, maintenance had been neither fully performed nor properly programmed and maintained. As a consequence, the water supply and sanitation systems were inefficient and functioning under serious constraints. To remedy these shortcomings, the Panamanian government, with the support of the Inter-American Development Bank (IADB), launched the Public Enterprise Reform Program for the water supply and sewerage sector. The program's objective was to scale back the public sector's role and to promote the participation of private operators in service delivery. The program, in particular, aimed to strengthen the Instituto de Acueductos y Alcantarillados Nacionales (IDAAN), the public utility responsible for providing water supply and sanitation services by rationalizing its staff, outsourcing support activities to the private sector, and collecting outstanding accounts. This chapter explains how the results of the financial and economic appraisal of a program aimed at improving the overall efficiency of the water utility with no expansion of coverage can differ significantly when viewed from different perspectives.

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CHAPTER 20

RESTRUCTURING THE WATER AND SEWER UTILITY IN PANAMA

20.1 Introduction

In the 1980s, investments in Panama's water supply and sanitation sector centered on expanding the system capacity to meet the growing demand. However, since the facilities were constructed, maintenance had been neither fully performed nor properly programmed and maintained. As a consequence, the water supply and sanitation systems were inefficient and functioning under serious constraints.

To remedy these shortcomings, the Panamanian government, with the support of the Inter-American Development Bank (IADB), launched the Public Enterprise Reform Program for the water supply and sewerage sector. The program's objective was to scale back the public sector's role and to promote the participation of private operators in service delivery. The program, in particular, aimed to strengthen the Instituto de Acueductos y Alcantarillados Nacionales (IDAAN), the public utility responsible for providing water supply and sanitation services by rationalizing its staff, outsourcing support activities to the private sector, and collecting outstanding accounts.¹

By 1996 the government had partially achieved the Public Enterprise Reform Program's targets. In response, it launched a more comprehensive reform program to promote competitive market structures and encourage private sector participation and delivery of services. To this end, the government passed specific legislations including:

¹IDAAN had poor performance in collecting water tariffs because of its lack of financial autonomy to set up budgets efficiently and comply with maintenance plans, its incapability of applying an adequate tariff structure, its outdated technical and customer records, its weak administration in effective metering and collection of tariff, ineffectual coordination to protect water resources, as well as excessive numbers of staff.

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- Law 26 of January 1996, establishing the Public Utilities Regulatory Agency. This agency was created as a financially and operationally independent body. It is responsible for ensuring compliance with the law and its regulations. This provision would protect consumers, promote service under competitive conditions, prevent the IDAAN from abusing its monopolistic position, approve and monitor compliance with tariff regimes, control the quality of service, and report regularly to the Ministry of Health and other parties.
- Law 29 of February 1996, pertaining to unrestricted competition and consumer affairs.
- Decree-Law 2 of January 1997, establishing a regulatory and institutional framework for the provision of water and sewerage services.

One of the core components of the reform was the restructuring and privatization of IDAAN. It planned to reduce the work force, provide training to the remaining staff and help those made redundant with worker outplacement services, and bring in a strategic operator from the private sector. IDAAN would be transformed into a corporation, with the private sector controlling at least 51 percent of the share capital. The corporation would be responsible for planning future investments.

After the process of restructuring and privatizing the public utility had started, the water supply systems would be rehabilitated on a priority basis so as to facilitate efficiency improvements. Estimates suggest that between 1997 and 2002, an investment of approximately US\$200 million would be required to improve the water supply and sewerage systems. IDAAN's current financial situation does not permit it to finance investment of this magnitude. An IADB program is proposed to provide support for the creation of a mixed capital corporation to carry out the rehabilitation of water and sewerage systems. The main purpose of this chapter is to assess whether this water and sewer utility program is financially and economically feasible and sustainable.

20.2 Program Description

The project area, designated as Metropolitan Panama, includes urban zones, suburban areas, and neighboring rural communities along the strip from Arraijan to Chorrera to the west of the Panama Canal, and in the corridor extending from Colon to Panama City east of the Canal. This is a high-priority area, because nearly half of the country's population and 70 percent of its urban population are located there.²

In 1985 IDAAN's water treatment plants and facilities, together with those of the Panama Canal Authority that served the project area, had an available supply of 206 million gallons a day. For a population of about 1.2 million residents, the gross availability of water was about 166 gallons per person per day. Given these figures, the net daily supply of water available per person should be more than sufficient if the system were being operated efficiently.

The key objectives of the program are (a) to support the restructuring of IDAAN and the private sector entity that would be involved in the management and funding of future investments, (b) to habilitate and optimize the water supply systems, and (c) to provide technical cooperation. To achieve these objectives, the program has been divided into the three subprograms described below.

Subprogram 1: Restructuring the Public Utility. This subprogram includes downsizing IDAAN and establishing the Sociedad Anonima de Panama Metropolitano (SAPM), which will be fully owned by the private investors. The deal being discussed with the government is described as follows: the investors would pay nothing up front for their 100% stake in the new company, but would get the right to all the net cash flow

² Although IDAAN is supposed to serve 100 percent of the urban population and 94.4% of the rural population in the project area, its coverage is not as wide due to the IDAAN's inefficiency and poor-quality service.

beginning in 1998. In return, they would be obliged to obtain financing for implementing the investments of subprogram 2.

Subprogram 2: Rehabilitation Works. This subprogram consists of the rehabilitation of the systems supplying water to Arraijan, Chorrera, Colon, and Panama City. On the technical and operational side, it entails upgrading the distribution networks and developing geographic information systems, technical records, system metering, and operating and control units for the entire Metropolitan Panama area. On the commercial side, it involves upgrading or developing customer records, end-user metering, flow measurement, and detecting and reducing water losses in each of the following four targeted systems. The scope of the physical works in each of the systems is as follows:

- *Arraijan system.* This includes the purchase and installation of approximately 5,800 customer meters and 4 stations for macro-metering; the rehabilitation of the Miraflores pumping station, a 1 million-gallon storage tank, 15 kilometers of water mains and pipes, and household connections; and the replacement of 83 control valves.
- *Chorrera system.* This includes the purchase and installation of approximately 8,200 households meters and 8 stations for macro-metering; the rehabilitation of the El Caimito treatment plant, groundwater pumping plants, an 800,000-gallon storage tank, 33 kilometers of water mains and pipes, household connections; and the replacement of 90 control valves.
- *Colon system.* This includes the purchase and installation of approximately 7,000 meters and 4 stations for macro-metering; the rehabilitation of a 300,000-gallon storage tank; and the replacement of 99 control valves.
- *Panama City System.* This includes the purchase and installation of approximately 34,000 household meters and 36 stations for macro-metering; the rehabilitation of pumping stations, the Chilibre treatment plant, 66-inch and 60-inch transmission pipelines, booster pumping stations and storage tanks; and the replacement of 946 control valves.

Subprogram 3: Additional Activities. This subprogram includes improving inter-institutional coordination and the authority responsible for protecting water resources and the water quality of receiving bodies, and developing feasibility studies and updating the master plan for Panama City's sewerage system.

20.3 Program Costs and Financing

The estimated total cost of the three subprograms is almost US\$65 million in 1998 prices; of which the cost of subprogram 2, the focus of this case study, is estimated at US\$48 million. The projected cost in domestic currency of Subprogram 2 is B21 million, or about 47 percent of the total.³ The cost estimates are based on contracts with similar characteristics recently awarded in the region following international bidding. Table 20.1 presents the total capital costs by component of subprogram 2.

**Table 20.1: Total Costs of Subprogram 2 by Component
(1998 prices)**

Category	Foreign Currency (US\$ thousands)	Domestic Currency (B thousands)
Engineering and administration	0	3,534
Direct Costs:		
Panama		
UFW reduction	3,168	5,393
New physical infrastructure	2,991	1,408
System rehabilitation	7,615	3,373
Colon		
UFW reduction	1,100	1,290
System rehabilitation	67	79
Arraijan		
UFW reduction	744	874
New physical infrastructure	2,835	1,467
System rehabilitation	693	250
Chorrera		
UFW reduction	784	836
New physical infrastructure	3,120	1,468
System rehabilitation	95	51
Concurrent costs	0	630
Contingency 10%	2,321	2,065
Total Investment Costs	25,533	22,718

³ The Panamanian currency unit is the balboa. The exchange rate is B 1 = US\$1.

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Notes: UFW stands for unaccounted-for water.

The Inter-American Development Bank (IADB) will provide financing for 70 percent of the total cost of the program, which at the government's request, will be drawn on the Single Currency Facility. The proposed terms of the financing are a 4-year disbursement period, a 19-year amortization period, 1-year grace period, and variable interest rates. The remaining financing needed for the program will come from investor equity contributions.

20.4 Financial Appraisal of the Program

The financial analysis is the first component of the integrated appraisal of this program. The principal focus of the analysis is to examine whether the incremental impact of the program is financially feasible and sustainable. The incremental impact is to measure the impacts of the program that occur over and above what would have occurred in the absence of the program. This means that one should identify only the effects that are associated with the initiative of the program and not include any other effects that would exist whether or not the initiative is undertaken.

20.4.1 Program Parameters and Assumptions

The starting point of the analysis is to develop the incremental financial cash flow statement of the program from the total investment point of view. It is carried out on an incremental basis in which "with" and "without" the program scenarios must be identified. To do so, the following rationale, hypotheses and key assumptions used in the analysis are made.

Restructure of the Water System

One would expect the proposed program to substantially improve the water supply and sanitation services as well as enhance the administrative efficiency of IDAAN.

- **Metering and Conservation:** About 45 percent of the residential connections in Metropolitan Panama are currently not metered. To implement a volumetric tariff system, metering is necessary. In order to have effective metering of the water, all metered customers will receive a 24 hours water service. Under the current system of fixed monthly charges for water service, unmetered consumers do not face any incremental costs when they consume additional water. After the program is implemented, consumers who switch from a flat-fee to a volumetric tariff will have to pay more for higher levels of water consumption, and are therefore likely to reduce their consumption. Thus metering would provide an incentive for water conservation by reducing the relatively low-value uses of water and diverting it to higher-value uses elsewhere. In addition, because we are economizing in prior uses of water, less water will be tapped from the distribution system's sources of bulk supply. Metering will also give SAPM much better operating information both for efficient management of the system and for better planning of its expansion.
- **Water Leakage:** The current distribution network in Metropolitan Panama experiences substantial water leakage. The working assumption is that the current level of physical water losses is approximately 15 percent of all the water supplied. If the level of water pressure and hours of operation were increased, the water losses would be much greater. The project will include a comprehensive leak detection and repair program with the objective of reducing the rate of the leakage to 10 percent of water supplied.
- **Unregistered Consumers:** At present about 30 percent of potential revenue is lost through unregistered connections as a consequence of inefficient billing and collection. The project includes a component to lower this figure to 15 percent.

Restructuring the Tariff

- Subprogram 2 aims at raising the percentage of residential connections with meters from the current 46 percent of all households to about 91 percent which will receive a 24-hour water supply service. This represents an increase of 45

percentage points, of which 13 percent were previously unmetered but had 24-hour supply, 15 percent were previously receiving an intermittent water supply but coped by using tanks, and 9 percent had only intermittent water supply but did not have tanks. Thus, if the project is fully implemented, only 9 percent of all customers of IDAAN will still not be metered.

- The current tariff structure has remained unchanged since 1982. Unmetered residential customers pay, on average, a flat-fee of B7.00 per month. Metered residential customers pay a volumetric tariff at B0.80 per 1,000 gallons for consumption up to 10,000 gallons per month, B1.51 per 1,000 gallons for consumption of 10,000 to 30,000 gallons a month, and B1.67 per 1,000 gallons for consumption of more than 30,000 gallons per month. Industrial customers pay B1.51 per 1,000 gallons, and government customers pay B1.36 per 1,000 gallons. According to the IADB loan agreement, when the program is implemented the tariff structure will be increased on a one time basis by 10 percent and adjusted annually thereafter to reflect the rate of domestic inflation.
- We assume that unmetered residential customers (both those who receive a 24-hour supply of water and those who face intermittent water supplies) now consume 20 percent more water than residential metered customers. Unmetered customers without coping devices are estimated to consume 45 gallons per person per day. As the program entails an increase in the tariff structure, we expect water users to reduce their consumption levels depending on the price elasticity of demand by the different categories of customers. We assume that the own-price elasticity of water demand by metered residential customers is -0.35, for industrial and commercial customers it is -0.60, and for government customers it is -0.50.

Investment Costs and Residual Values of Assets

- The construction of the program was to begin in 1998 and last for four years. The total investment cost of the program is about US\$48 million in 1998 prices. The detailed expenditures by year and by component are presented in Table 20.2.
- The operation of the program is assumed to be for a period of 20 years. The fixed assets are expected to have a longer useful life. It is assumed that they will be

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depreciated by 90 percent of their initial cost in real terms by the end of the program.

- The capital costs during the construction period exclude interest payments.

**Table 20.2: Capital Costs of Subprogram 2 by Year and by Component
(US\$ thousands in 1998 prices)**

Category	1998	1999	2000	2001	Total
Engineering and administration	1,049	1,322	1,049	114	3,534
Direct Costs:					
Panama					
UFW reduction	1,349	2,022	3,842	1,348	8,566
New physical infrastructure	642	1,284	2,152	321	4,399
System rehabilitation	1,604	3,208	5,374	802	10,988
Colon					
UFW reduction	478	717	717	478	2,390
System rehabilitation	29	116	0	1	146
Arraijan					
UFW reduction	324	485	485	324	1,618
New physical infrastructure	860	1,721	1,291	430	4,302
System rehabilitation	189	566	188	0	943
Chorrera					
UFW reduction	341	425	512	342	1,620
New physical infrastructure	918	1,835	1,376	459	4,588
System rehabilitation	29	116	0	1	146
Concurrent costs	180	180	180	90	630
Contingency 10%	799	1,400	1,717	471	4,387
Total Investment Costs	8,791	15,397	18,883	5,181	48,252

Lowering Operating and Maintenance Costs

- Subprogram 2 is expected to reduce the cost of personnel, electricity by 15 percent, and administration costs by 20 percent. These cost savings are assumed to take place immediately when the project is implemented in 2002. The costs of operating inputs other than labor are expected to remain unchanged in real terms throughout the life of the program.
- The SAPM is assumed to continue to be exempt from the corporate income taxes.

Working Capital

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- The average collection time for the water tariff is currently 140 days. The program aims to reduce it to 70 days.⁴
- About 70 percent of bills currently sent to residential water customers are collected. The program aims to increase the collection efficiency to 80 percent.⁵We assume that 100 percent of water bills sent to industrial and government customers were collected prior to the project's implementation.
- The accounts payable are assumed to be equal to two months of operating expenses, excluding labor expenses.
- The desired level of cash balances to be held as working capital is assumed to be one month of all operating expenses, including labor expenses.

Foreign Exchange Rates and Required Rate of Return

- The nominal exchange rate with respect to the U.S. dollar is fixed in Panama. The nominal exchange rate is B 1 to US\$1 in the starting year of the analysis. The real exchange rate may vary over time if Panama's inflation rate differs from that of the world price level of tradables.
- The financial opportunity cost of equity capital is 15 percent real.

20.4.2 Financial Feasibility

The cash flow statements of the project entity have been estimated first for the “with” and “without” subprogram 2 from the total investment perspective. Their difference would then measure the incremental contribution of the program.

The financial analysis of the program is first conducted in nominal prices to account for the direct and indirect impacts of inflation. The direct impact of inflation on the financial outcome takes place through changes in relative prices of the program outputs and inputs,

⁴The program will strengthen the collection of the water tariff. As a result, the amount of accounts receivable becomes smaller and the change in accounts receivable in the first year of operation will be negative in the incremental case scenario as compared to the normal stand alone case.

⁵It is assumed that the efficiency starts from the beginning of the program.

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plus changes in the value of accounts receivable, accounts payable, and cash balances. The indirect impacts of inflation that alter the tax payments are not relevant in this case, because the concessionaire, SAPM, does not pay corporate income tax. The nominal incremental net cash flow is further adjusted for the loan disbursements received and interest and principal payments made to the IADB in order to derive the net financial cash flow after debt financing. The nominal incremental cash flows are deflated item by item to arrive at the real incremental cash flow statements as presented in Table 20.3. It addresses the question if the incremental flow of financial revenues generated by the program over its life is big enough to recover the capital and operating expenditures of the program and also to generate an adequate rate of return to the concessionaire's investment. The financial NPV discounted at a real rate of 15% is estimated to be B84.3 million in 1998 prices. This implies that from the investor's perspective, the program is expected to generate a rate of return to equity capital, which is well above its 15% real rate of opportunity cost.

To determine the bankability of the project, the analysis focuses on the capability of the utility to meet its debt repayment obligations. In the present case, it is important to look at the financial benefits and costs incurred by the entire utility inclusive of the investments made by the program. The debt coverage ratios are therefore calculated for the utility with the program.

The resulting financial cash flow statement from the lender's viewpoint, together with the resulting debt service ratios are presented in Table 20.4. The Annual Debt Service Coverage Ratio (ADSCR) is calculated as the ratio of the annual net cash flows to the annual debt repayment obligations including principal and interest payment. The values of this ratio range from 6.34 to 19.31 over the loan repaying period. They are much greater than 1.4, the minimum rate recommended for this type of project.

The loan life cover ratio (LLCR) is also calculated in which LLCR is defined as the present value of the net real cash flow during the loan repayment period divided by the

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present value of the remaining debt obligation, discounted by the real interest rate charged on the loan. The ratios are all larger than 9.60 over the loan period. This indicates that the concessionaire is able to generate more than sufficient cash flows to cover the loans and interest payment.

The above debt services ratios, along with the estimated financial NPV, indicate that the proposed program is financially feasible and bankable.

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**Table 20.3: Incremental Financial Cash Flow Statement from the Equity Perspective
(thousands of Balboas in 1998 prices)**

Category	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2019	2020	2021	2022
RECEIPTS																	
Sales revenues																	
Residential unmetered customers					210	311	321	331	331	331	331	331	331	331	331	331	0
Residential metered customers																	
Metered customers w/o project					1,697	2,716	2,800	2,882	2,882	2,882	2,882	2,882	2,882	2,882	2,882	2,882	0
Unmetered customers with 24-hour supply w/o project					1,658	1,940	2,005	2,069	2,069	2,069	2,069	2,069	2,069	2,069	2,069	2,069	0
Unmetered customers with intermittent supply w/o project (cope with tanks)					1,895	2,217	2,292	2,364	2,364	2,364	2,364	2,364	2,364	2,364	2,364	2,364	0
Unmetered customers with intermittent supply w/o project (do not cope with tanks)					1,184	1,386	1,432	1,478	1,478	1,478	1,478	1,478	1,478	1,478	1,478	1,478	0
Commercial and industrial customers					440	456	471	487	487	487	487	487	487	487	487	487	0
Government					224	228	232	236	236	236	236	236	236	236	236	236	0
Total sales revenues					7,307	9,254	9,554	9,846	9,846	9,846	9,846	9,846	9,846	9,846	9,846	9,846	0
Revenues from recoup of commercial losses					9,490	10,446	10,774	11,095	11,095	11,095	11,095	11,095	11,095	11,095	11,095	11,095	0
Cost savings from reduced bulk water purchase					578	578	578	578	578	578	578	578	578	578	578	578	0
Change in accounts receivable					3,427	-301	150	153	64	64	64	64	64	64	64	64	-3,176
Liquidation value					0	0	0	0	0	0	0	0	0	0	0	0	4,387
Cash inflow					20,802	19,978	21,057	21,672	21,583	21,583	21,583	21,583	21,583	21,583	21,583	21,583	1,210
					0	0	0	0	0	0	0	0	0	0	0	0	0
EXPENDITURES																	
Investment cost					0	0	0	0	0	0	0	0	0	0	0	0	0
Engineering and administration	1,049	1,322	1,049	114	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Samz - UFW reduction	1,349	2,022	3,842	1,348	0	0	0	0	0	0	0	0	0	0	0	0	0
New physical infrastructure	642	1,284	2,152	321	0	0	0	0	0	0	0	0	0	0	0	0	0
System rehabilitation	1,604	3,208	5,374	802	0	0	0	0	0	0	0	0	0	0	0	0	0
Comba - UFW reduction	478	717	717	478	0	0	0	0	0	0	0	0	0	0	0	0	0
System rehabilitation	29	116	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ayumba - UFW reduction	324	485	485	324	0	0	0	0	0	0	0	0	0	0	0	0	0
New physical infrastructure	860	1,721	1,291	430	0	0	0	0	0	0	0	0	0	0	0	0	0
System rehabilitation	189	566	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chumba - UFW reduction	341	425	512	342	0	0	0	0	0	0	0	0	0	0	0	0	0
New physical infrastructure	918	1,835	1,376	459	0	0	0	0	0	0	0	0	0	0	0	0	0
System rehabilitation	29	116	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Concurrent costs	180	180	180	90	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency	799	1,400	1,717	471	0	0	0	0	0	0	0	0	0	0	0	0	0
Total investment cost	8,791	15,397	18,883	5,181	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Personnel	0	0	0	0	-2,118	-2,209	-2,302	-2,395	-2,419	-2,444	-2,468	-2,493	-2,518	-2,754	-2,781	-2,809	0
Electricity	0	0	0	0	-1,370	-1,414	-1,459	-1,502	-1,502	-1,502	-1,502	-1,502	-1,502	-1,502	-1,502	-1,502	0
Chemicals	0	0	0	0	-232	-240	-248	-255	-255	-255	-255	-255	-255	-255	-255	-255	0
Materials	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marketing and administration	0	0	0	0	-1,020	-1,030	-1,040	-1,051	-1,061	-1,072	-1,083	-1,093	-1,104	-1,208	-1,220	-1,232	0
Income tax liability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Change in accounts payable	0	0	0	0	267	14	14	14	6	6	6	6	6	6	6	6	-287
Change in cash balance	0	0	0	0	-395	-20	-21	-21	-11	-11	-12	-12	-12	-13	-13	-13	474
Cash Outflow	8,791	15,397	18,883	5,181	-4,869	-4,900	-5,056	-5,211	-5,244	-5,279	-5,314	-5,350	-5,386	-5,726	-5,765	-5,806	187
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NET CASH FLOW	-8,791	-15,397	-18,883	-5,181	25,671	24,877	26,112	26,883	26,827	26,862	26,897	26,933	26,969	27,309	27,349	27,389	1,024

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Table 20.3: Incremental Financial Cash Flow Statement from the Equity Perspective (continued)
(thousands of Balboas in 1998 prices)

Category	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Net cash flow before financing	-8,791	-15,397	-18,883	-5,181	25,671	24,877	26,112	26,883	26,827	26,862	26,897	26,933	26,969	27,005	27,042	27,079	27,116	27,154	27,192	27,231	27,270	27,309	27,349	27,389	1,024
Debt financing	6,154	10,778	13,218	3,627	0	-4,598	-4,372	-4,154	-3,942	-3,737	-3,539	-3,347	-3,161	-2,981	-2,807	-2,639	-2,476	-2,318	-2,166	-2,019	-1,877	-1,739	-1,607	-1,478	0
Net cash flow after debt financing	-2,637	-4,619	-5,665	-1,554	25,671	20,279	21,740	22,729	22,885	23,125	23,358	23,586	23,808	24,024	24,235	24,440	24,640	24,836	25,026	25,212	25,393	25,570	25,742	25,910	1,024
NPV @ 15.0%	15.0%	84,336																							

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**Table 20.4: Financial Cash Flow Statement of Utility with Project (Lender's perspective)
(thousands of Balboas in Current Prices unless otherwise Specified)**

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2019	2020	2021	
RECEIPTS																						
Sales revenues																						
Residential unmetered customers	5,066	5,327	5,602	5,913	1,498	1,681	1,768	1,856	1,894	1,931	1,970	2,009	2,050	2,091	2,132	2,175	2,219	2,263	2,449	2,498	2,548	
Residential metered customers																						
metered customers w/o project	10,949	11,493	12,067	12,689	15,214	17,071	17,948	18,840	19,217	19,601	19,993	20,393	20,801	21,217	21,641	22,074	22,516	22,966	24,859	25,356	25,863	
unmetered customers with 24-hour supply w/o project					3,534	3,977	4,193	4,412	4,500	4,591	4,682	4,776	4,871	4,969	5,068	5,170	5,273	5,379	5,822	5,938	6,057	
unmetered customers with intermittent supply w/o project (cope with tanks)					4,038	4,545	4,792	5,043	5,143	5,246	5,351	5,458	5,567	5,679	5,792	5,908	6,026	6,147	6,654	6,787	6,922	
unmetered customers with intermittent supply w/o project (do not cope with tanks)					2,524	2,841	2,995	3,152	3,215	3,279	3,345	3,411	3,480	3,549	3,620	3,693	3,766	3,842	4,158	4,242	4,326	
Commercial & industrial customers	11,309	11,914	12,544	13,262	14,487	15,297	16,143	17,026	17,367	17,714	18,069	18,430	18,799	19,174	19,558	19,949	20,348	20,755	22,466	22,915	23,374	
Government	4,650	4,816	4,992	5,189	5,634	5,847	6,072	6,297	6,423	6,551	6,682	6,816	6,952	7,091	7,233	7,378	7,526	7,676	8,309	8,475	8,644	
Total sales revenues	31,975	33,550	35,206	37,053	46,930	51,258	53,912	56,626	57,759	58,914	60,092	61,294	62,520	63,770	65,046	66,347	67,674	69,027	74,717	76,212	77,736	
Revenues from recoup of commercial losses	0	0	0	0	10,272	11,533	12,133	12,745	13,000	13,260	13,525	13,796	14,071	14,353	14,640	14,933	15,231	15,536	16,817	17,153	17,496	
Cost savings from reduced bulk water purchase	0	0	0	0	626	639	651	664	678	691	705	719	734	748	763	778	794	810	877	894	912	
Change in accounts receivable	0	-604	-635	-709	2,955	-1,107	-641	-655	-273	-279	-284	-290	-296	-302	-308	-314	-320	-327	-353	-360	-368	
Liquidation value -																						
Cash Inflow	31,975	32,946	34,571	36,344	60,783	62,323	66,055	69,381	71,163	72,586	74,038	75,519	77,029	78,570	80,141	81,744	83,379	85,047	92,057	93,988	95,776	
EXPENDITURES																						
Investment cost -																						
Engineering and administration	1,049	1,348	1,091	121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Direct costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Panama - UFW reduction	1,349	2,062	3,997	1,431	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
New physical infrastructure	642	1,310	2,239	341	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
System rehabilitation	1,604	3,272	5,591	851	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Colon - UFW reduction	478	731	746	507	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
System rehabilitation	29	118	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arraijan - UFW reduction	324	495	505	344	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
New physical infrastructure	860	1,755	1,343	456	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
System rehabilitation	189	577	196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Chorrera - UFW reduction	341	434	533	363	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
New physical infrastructure	918	1,872	1,432	487	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
System rehabilitation	29	118	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Concurrent costs	180	184	187	96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Contingency	799	1,428	1,786	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total investment cost	8,791	15,705	19,645	5,498	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Operating costs -																						
Personnel	11,979	12,710	13,488	14,351	12,994	13,821	14,693	15,592	16,063	16,548	17,048	17,563	18,094	18,640	19,203	19,783	20,380	20,996	23,649	24,363	25,099	
Electricity	5,210	5,470	5,744	6,049	4,892	5,148	5,416	5,689	5,803	5,919	6,037	6,158	6,281	6,407	6,535	6,665	6,799	6,935	7,506	7,656	7,810	
Chemicals	2,115	2,221	2,332	2,456	2,337	2,459	2,587	2,717	2,772	2,827	2,884	2,941	3,000	3,060	3,121	3,184	3,247	3,312	3,586	3,657	3,730	
Materials	3,208	3,370	3,541	3,730	3,934	4,143	4,360	4,581	4,673	4,767	4,862	4,959	5,058	5,159	5,263	5,368	5,475	5,585	6,045	6,166	6,289	
Marketing & administration	4,900	5,048	5,200	5,357	4,415	4,549	4,686	4,828	4,973	5,124	5,278	5,438	5,602	5,771	5,945	6,125	6,310	6,501	7,322	7,543	7,771	
Income tax liability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Change in accounts payable	0	-88	-93	-103	179	-98	-102	-104	-43	-44	-45	-46	-47	-48	-49	-50	-51	-52	-56	-57	-58	
Change in cash balance	0	117	124	136	-281	129	135	139	73	75	77	79	81	84	86	88	91	93	104	107	109	
Cash Outflow	36,203	44,553	49,982	37,474	28,469	30,151	31,776	33,443	34,314	35,215	36,141	37,092	38,069	39,073	40,104	41,163	42,252	43,370	48,156	49,436	50,751	
NET CASH FLOW (NOMINAL)	-4,228	-11,607	-15,411	-1,130	32,313	32,172	34,280	35,938	36,849	37,371	37,897	38,427	38,960	39,497	40,037	40,581	41,127	41,677	43,901	44,463	45,026	
NET CASH FLOW (REAL)	-4,228	-11,380	-14,813	-1,064	29,853	29,139	30,439	31,286	31,450	31,270	31,089	30,905	30,720	30,532	30,343	30,152	29,959	29,764	28,965	28,760	28,553	
Debt Service Coverage Ratios																						
Net Cash Flow before Financing (Real)					29,139	30,439	31,286	31,450	31,270	31,089	30,905	30,720	30,532	30,343	30,152	29,959	29,764	28,965	28,760	28,553		
Debt Repayment (Real)					4,598	4,372	4,154	3,942	3,737	3,539	3,347	3,161	2,981	2,807	2,639	2,476	2,318	1,739	1,607	1,478		
PV of Retaining Net Cash Flow @4.90%					386,392	374,766	361,205	346,091	330,064	313,441	296,193	278,292	259,708	240,410	220,364	199,536	177,890	152,328	115,979	82,328	55,979	28,553
PV of Remaining Debt repayment @4.90%					40,118	37,262	34,502	31,835	29,260	26,774	24,374	22,058	19,824	17,668	15,589	13,586	11,654	4,614	3,016	1,478		
Annual Debt Service Coverage Ratio					6.34	6.96	7.53	7.98	8.37	8.78	9.23	9.72	10.24	10.81	11.43	12.10	12.84	16.65	17.90	19.31		
Loan Life Cover Ratio					9.63	10.06	10.47	10.87	11.28	11.71	12.15	12.62	13.10	13.61	14.14	14.69	15.26	17.84	18.56	19.31		

20.4.3 Financial Sensitivity Analysis

The results of the base case financial analysis reported in Table 20.3 for the incremental impact of the project are determined by the single values of the parameters and assumptions made in the model. Those values can be different from reality and it is important to know how sensitive they are. A sensitivity analysis is conducted to identify the variables that are most likely to affect the program's financial performance.

Cost Overruns:The program's financial performance is not very sensitive to the likelihood of a higher than anticipated investment costs. This is under the assumption that any amount of the cost overruns would be financed by additional equity capital. Table 20.5 shows that a cost overrun of 20 percent reduces the financial NPV by only B8 million in 1998 prices. There is no impact on the debt service coverage ratios.⁶Because of the exemption of the utility from corporate income taxes, the net cash flows during the period of operation are not altered due to changes in income taxes caused by the cost overruns.

**Table 20.5: Sensitivity Test of Capital Cost Overrun
(1998 prices)**

Cost Overrun	FNPV (000 Balboas)	ADSCR 2003	ADSCR 2004	ADSCR 2005	LLCR 2003	LLCR 2004	LLCR 2005
0%	84,336	6.34	6.96	7.53	9.63	10.06	10.47
5%	82,343	6.34	6.96	7.53	9.63	10.06	10.47
10%	80,350	6.34	6.96	7.53	9.63	10.06	10.47
15%	78,357	6.34	6.96	7.53	9.63	10.06	10.47
20%	76,364	6.34	6.96	7.53	9.63	10.06	10.47
25%	74,370	6.34	6.96	7.53	9.63	10.06	10.47
30%	72,377	6.34	6.96	7.53	9.63	10.06	10.47
35%	70,384	6.34	6.96	7.53	9.63	10.06	10.47

Consumption per Connection:A change in the quantity of water consumed per connection has a significant impact on the financial performance. Table 20.6 shows that, for example,if water users were to consume 20 percent less water than in the base case

⁶ If the cost overruns are financially proportionally by the original debt and equity ratio, one would expect the financial NPV to decrease by B 4.9 million instead of B 8 million when the cost overruns were also increased by 20%. The ADSCR and LLCR would now be reduced to 5.28 and 8.38, respectively, in year 2004.

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scenario, the financial NPV of the program would drop by almost B22 million. As regards debt service ratios, both ADSCR and LLCR are reduced to almost half of their previous value, but are still very high. The opposite is true if water consumption per connection is raised.

**Table 20.6: Sensitivity Test of Consumption per Connection
(1998 prices)**

Consumption per Connection	FNPV (000 Balboas)	ADSCR 2003	ADSCR 2004	ADSCR 2005	LLCR 2003	LLCR 2004	LLCR 2005
-30%	52,126	3.28	3.61	3.90	4.84	5.04	5.23
-20%	62,806	4.29	4.72	5.10	6.43	6.71	6.97
-10%	73,547	5.31	5.84	6.32	8.03	8.38	8.72
0%	84,336	6.34	6.96	7.53	9.63	10.06	10.47
10%	95,162	7.36	8.08	8.75	11.24	11.74	12.22
20%	106,015	8.39	9.21	9.97	12.85	13.42	13.98
30%	116,888	9.42	10.33	11.19	14.45	15.11	15.74
40%	127,778	10.45	11.46	12.41	16.07	16.79	17.50

Water Tariffs:With the program water tariffs are assumed to be raised by 10 percent from the existing tariff structure. This is a critical variable affecting the financial performance of the program. Table 20.7 presents the financial NPV as well as the debt service ratios over a range of changes in the level of the tariff structure. If the tariff structure remains as it is, the financial NPV would drop by more than B 14.1 million from the base case scenario or 29% of the program's investment costs. The table also indicates that the projected improvement in efficiency brought by the proposed program is such that IDAAN could reduce the tariff structure by almost 40% and will be no worse off financially than it is today.

**Table 20.7: Sensitivity Test of Tariff Structure
(1998 prices)**

Tariff Structure	FNPV (000 Balboas)	ADSCR 2003	ADSCR 2004	ADSCR 2005	LLCR 2003	LLCR 2004	LLCR 2005
-40%	-2,058	1.87	2.07	2.23	2.64	2.74	2.83
-25%	27,999	3.42	3.77	4.07	5.07	5.28	5.49
-20%	37,229	3.90	4.30	4.64	5.82	6.07	6.30
-15%	46,066	4.36	4.80	5.18	6.53	6.81	7.08
-10%	54,508	4.79	5.27	5.70	7.22	7.53	7.83
-5%	62,556	5.21	5.73	6.20	7.87	8.21	8.54
0%	70,210	5.61	6.16	6.66	8.49	8.86	9.22
5%	77,470	5.98	6.57	7.11	9.08	9.48	9.86
10%	84,336	6.34	6.96	7.53	9.63	10.06	10.47

Water Leakage/Commercial Losses: The utility's ability to reduce commercial losses has a considerable impact on the financial returns of the program. If the commercial losses after the program were raised from 15 percent of the water produced as assumed in the base case to 21 percent, the NPV would be reduced by about 20% to B67 million (Table 20.8). The debt service ratios are reduced, but they are still high. Clearly this is a critical variable that should not be ignored.

**Table 20.8: Sensitivity Test of Commercial Losses
(1998 prices)**

Commercial Losses	FNPV (000 Balboas)	ADSCR 2003	ADSCR 2004	ADSCR 2005	LLCR 2003	LLCR 2004	LLCR 2005
30%	41,305	4.11	4.52	4.89	6.14	6.40	6.65
27%	49,911	4.56	5.01	5.41	6.84	7.13	7.42
24%	58,518	5.00	5.50	5.94	7.54	7.87	8.18
21%	67,124	5.45	5.99	6.47	8.24	8.60	8.94
18%	75,730	5.89	6.47	7.00	8.93	9.33	9.71
15%	84,336	6.34	6.96	7.53	9.63	10.06	10.47
12%	92,943	6.78	7.45	8.06	10.33	10.79	11.23
9%	101,549	7.23	7.94	8.59	11.03	11.52	12.00

Technical Losses: Table 20.9 shows that a reduction in leakages or technical losses above the targeted 10 percent does not affect the financial viability of the program significantly. A reduction in the technical losses lowers the operating and maintenance costs and forces some water users with illegal connections to become subject to the new

volumetric tariff. Because the level of technical losses is rather low to start with, changes in the rate of technical losses do not affect either ADSCR or LLCR significantly.

**Table 20.9: Sensitivity Test of Technical Losses
(1998 prices)**

Technical Losses	FNPV (000 Balboas)	ADSCR 2003	ADSCR 2004	ADSCR 2005	LLCR 2003	LLCR 2004	LLCR 2005
18%	81,614	6.20	6.81	7.37	9.42	9.83	10.23
16%	82,292	6.23	6.85	7.41	9.47	9.89	10.29
14%	82,972	6.27	6.89	7.45	9.52	9.94	10.35
12%	83,653	6.30	6.92	7.49	9.58	10.00	10.41
10%	84,336	6.34	6.96	7.53	9.63	10.06	10.47
8%	85,021	6.37	7.00	7.57	9.69	10.11	10.53
6%	85,708	6.41	7.04	7.61	9.74	10.17	10.59
4%	86,396	6.44	7.08	7.66	9.79	10.23	10.65

Inflation Rate: As Table 20.10 shows, the overall impact of the domestic rate of inflation on the financial NPV of the project is relatively small. A more than a threefold increase in inflation from 2 to 6 percent would increase the program's financial NPV by B3.7 million to about B88 million or a change of 5 percent. This atypical impact of inflation on the financial NPV reflects the fact that the program will significantly reduce the amount of accounts receivable the utility requires. Therefore, an increase in the inflation rate has a positive impact on the program's returns, because the negative real changes in accounts receivable without the program are larger in absolute terms than the real changes with the program.

Since Panama is assumed to maintain a fixed nominal exchange rate to the U.S. dollar, an increase in the domestic inflation rate with respect to the U.S. inflation will bring about an appreciation of the local currency in real terms and will have a positive impact on the financial performance because of the relatively cheaper tradable inputs. Finally, the impact of inflation on the debt service ratios is quite significant although it has only a small effect on the financial NPV.

**Table 20.10: Sensitivity Test of Domestic Inflation
(1998 prices)**

Domestic Inflation	FNPV (000 Balboas)	ADSCR 2003	ADSCR 2004	ADSCR 2005	LLCR 2003	LLCR 2004	LLCR 2005
1%	83,107	6.05	6.59	7.06	8.67	8.98	9.28
2%	84,336	6.34	6.96	7.53	9.63	10.06	10.47
3%	85,434	6.63	7.35	8.03	10.67	11.22	11.77
4%	86,417	6.93	7.77	8.57	11.77	12.49	13.19
5%	87,301	7.25	8.20	9.13	12.96	13.85	14.75
6%	88,098	7.58	8.64	9.72	14.22	15.32	16.44
7%	88,818	7.91	9.11	10.34	15.57	16.90	18.29
8%	89,472	8.26	9.60	11.00	17.00	18.60	20.28

Collection Period: If the average collection period does not fall from its current level of 140 days to its target level of 70 days, but instead declines only to 110 days, the program's financial NPV would experience a modest decline of about B4 million as shown in Table 20.11. Similarly, the impact on the debt service ratios is also small.

**Table 20.11: Sensitivity Test of Collection Period
(1998 prices)**

Collection Period (days)	FNPV (000 Balboas)	ADSCR 2003	ADSCR 2004	ADSCR 2005	LLCR 2003	LLCR 2004	LLCR 2005
70	84,336	6.34	6.96	7.53	9.63	10.06	10.47
80	83,334	6.31	6.94	7.51	9.62	10.04	10.46
90	82,231	6.28	6.92	7.49	9.60	10.03	10.44
100	81,328	6.24	6.91	7.47	9.58	10.02	10.43
110	80,325	6.21	6.89	7.45	9.57	10.00	10.42
120	79,322	6.18	6.87	7.43	9.55	9.99	10.40
130	78,319	6.15	6.85	7.41	9.54	9.98	10.39
140	77,317	6.12	6.83	7.39	9.52	9.96	10.38

When sensitivity analysis is also carried out for changes in real wage rates and assumed savings in operating and maintenance expenses brought about by the program, the impacts on the financial NPV are also small.

With the financial structure as proposed, this reform would yield a net present value of B84.3 million. This is in addition to earning a 15 percent real rate of return on the amount

invested to the program. If this were a competitive industry, this kind of a return would almost certainly never occur. However, this is a public utility monopoly. As shown in Table 20.7 of the sensitivity analysis, if the restructuring of the utility was carried out according to plan, the water tariff rates could be reduced by up to 40% from their initial level and still give the private operator a 15 percent real rate of return on the equity investment. Hence, from the financial analysis alone it would appear that the financial proposal of the institutional restructuring plan is seriously flawed.

20.5 Economic Appraisal

The second component of the integrated investment analysis is the economic appraisal of the program, which is to assess whether the resources used by the program would generate the greatest net economic benefits to all members of society among the alternative options. The analysis is carried out under the assumption that the current market conditions and the current tax systems including among others, personal income tax, corporate income tax, value added tax, excise duties, import duties, and production subsidies, will remain unchanged over the life of the program. The measurements of benefits and costs of the program are based on principles well established in applied welfare economics.⁷

In this integrated investment approach, the measurement of economic benefits and costs is built on the information developed in the financial appraisal, using the domestic currency at the domestic price level as a numeraire. The objective is to measure the incremental economic impacts of the program, measured from a base that reflects how the relevant variables would have moved over time in the absence of the program. The analysis requires calculating the value of key national economic parameters –e.g., economic opportunity costs of capital and foreign exchange, the economic value of water,

⁷See e.g. Harberger, A.C., “Three Basic Postulates for Applied Welfare Economics.” *Journal of Economic Literature*, Vol. IX, No. 3, (September, 1971); Dinwiddie, C. And Teal, F., *Principles of Cost-Benefit Analysis for Developing Countries*, Cambridge: Cambridge University Press, (1996); Townley, P.G.C., *Principles of Cost-Benefit Analysis in a Canadian Context*, Scarborough: Prentice Hall Canada Inc., (1998); Mishan, E.J. and Quah, E., *Cost-Benefit Analysis*, Fifth Edition, London and New York: Routledge, (2007).

and the conversion factors for all the inputs used. We then use these factors to convert the outlays of the financial cash flow statement into a statement of economic costs.

20.5.1 National Parameters

The economic opportunity cost of capital for Panamais estimated at approximately 9.26 percent. It is calculated as a weighted average of the rate of time preference for consumption to savers (3.54%), the gross-of-tax returns on displaced or postponed investment (9.49%), and the marginal economic cost of foreign capital inflows (9.38%).⁸ The weights are determined by the response of each source to changes in market interest rates. For the purpose of this analysis, 9.3% is the rate used for discounting the stream of the economic costs, the economic benefits and all externalities generated by the program over the life of the program.

The foreign exchange premium for Panama is estimated at 5.4%⁹ and the premium for non-tradable outlays is taken as zero.

20.5.2 The Economic Value of Water

The economic value of water is mainly determined by the demand for water faced by different customers under different conditions before and after the program is implemented. The supply of water under the existing system serves: (a) residential metered and unmetered customers, (b) industrial and government customers, (c) unregistered (nonpaying) consumers, and (d) physical leaks from the system. Different types of water demanders will place a different value on the water service they receive, depending on

⁸Examples can be found in Chapter 8, or Burgess, D.F., "Toward a Reconciliation of Alternative Views on the Social Discount rate", ed. by David Burgess and Glenn P. Jenkins, "Discount Rates for the Evaluation of Public Private Partnerships", John Deutsch Institute for the Study of Economic Policy, McGill-Queen's University Press, (2010).

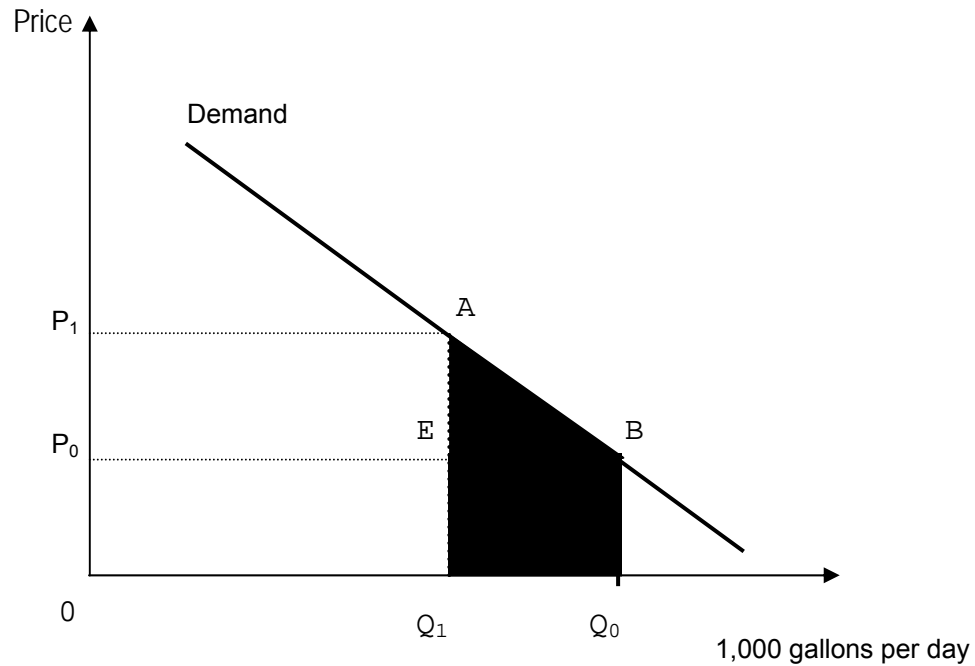
⁹The estimate was based on the amount of customs and other import duties, together with the values of imports and exports over the period from 2001 to 2003. See International Monetary Fund, "Panama: Selected Issues and Statistical Appendix", IMF Country Report No. 06/3, (January 2006).

the price they are willing to pay for it and on costs of coping with intermittent services.¹⁰ This can be very different from tariffs projected in the financial analysis. In order to meter the customers effectively the IDAAN will need to maintain an adequate level of water pressure for 24 hours a day. Hence, the program will involve an improvement in the reliability of the water service, metering and a reform in the system for the pricing of water.

Metered Customers under the Existing System

Metered customers include those residential customers with meters in the existing system, plus all industrial and government customers that currently receive water 24-hours a day. These customers now pay for their water on the basis of a volumetric set of tariffs. As the program entails a 10 percent increase in the tariff structure their level of consumption is likely to fall, depending on their price elasticity of demand. Figure 20.1 shows the economic loss incurred with respect to these customers after the implementation of the program.

¹⁰It is the demand price that measures the value of demanders for the goods or services they demand. See, e.g. Harberger, A.C., "Three Basic Postulates for Applied Welfare Economics", *Journal of Economic Literature*, Vol. IX, No. 3, (September, 1971).

Figure 20.1: Demand for Water by Metered Customers

Without the program, the demand for water by those customers with meters is denoted by Q_0 . These consumers lower their consumption by the quantity $(Q_0 - Q_1)$ because of a 10% increase in tariffs. The overall savings in the production costs due to less water being prepared for consumption is accounted for when the estimation is made of the incremental change in total cost of production brought about by the project. The loss in consumer surplus by the metered customers is shown by the area P_1ABP_0 in Figure 20.1, of which P_1AEP_0 is a transfer between the vendors and the customers and hence is not a cost for the society as a whole. The net loss is the consumer surplus in the triangular ABE . In addition, the reduction in the demand for water will lose the area of EBQ_0Q_1 . Thus, the total economic loss created by a higher water tariff charged to the demanders is the economic loss from the reduction in the quantity consumed, $Q_0 - Q_1$, measured by the area ABQ_0Q_1 under the demand curve for water. This category of metered customers including residents, government and commercial establishments make up a total of 45 percent of all IDAAN' customers.

Unmetered Customers under the Existing System

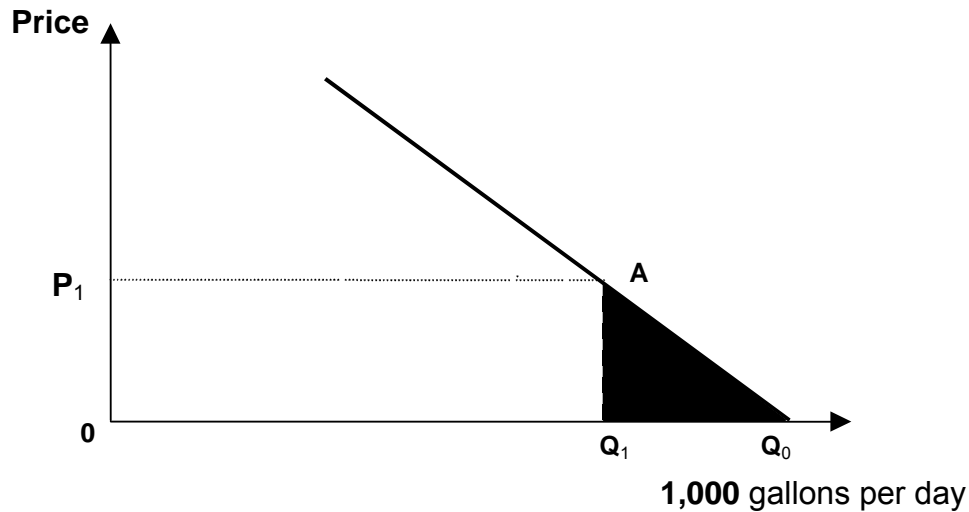
There are three kinds of unmetered customers under the current system. Each case entails a different way of measuring the economic benefits for water users.

(a) Demand for Water by Unmetered Customers Who Receive 24-Hour a Day Service without the Project

Figure 20.2 presents the economic analysis for the unmetered consumers who before the program received a 24-hour a day supply of water, and paid a fixed charge of B 7 per household per month. After the program is implemented they will have to pay a new volumetric tariff. Suppose these customers obtain a supply of water, Q_0 at the current flat-fee rate, there is a zero marginal cost for any additional water consumed. Once they are metered and facing a tariff schedule with a higher marginal tariff of P_1 , then the quantity they consume would decrease from Q_0 to Q_1 . This would result in a loss of economic benefits, which is measured by the triangular area Q_1AQ_0 . Again, a loss of the consumer surplus OP_1AQ_1 resulting from a higher price of water is a transfer from the customers to the vendors of water and is not an economic cost when viewed for society as a whole.

At the same time, when the program is implemented these customers will save the fixed monthly charge of B 7. This can be viewed as a gain in consumer surplus that is offset by a loss to the vendors created by the volumetric tariff. These people represent approximately 13 percent of the total connected residents who obtain water from IDAAN.

Figure 20.2: Demand for Water by Unmetered Customers Who Receive 24-Hour a Day Service without the Program



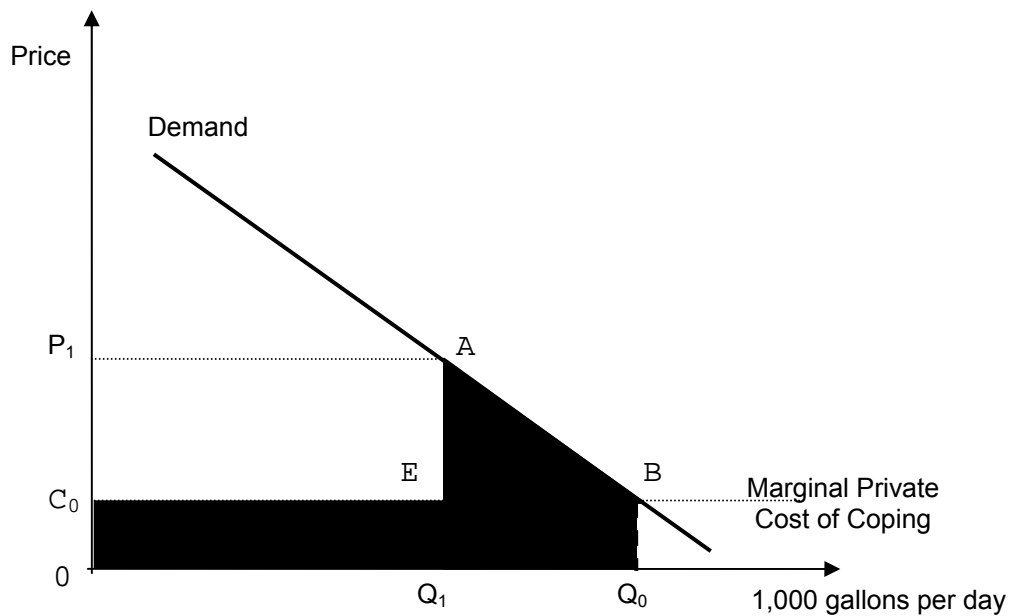
(b) Demand for Water by Unmetered Customers Who Cope with Intermittent Supply Using Overhead Tanks without the Program

Figure 20.3 shows the situation for those customers who currently cope with an intermittent water supply by using overhead tanks and who will now have to pay a new volumetric tariff with the program. With the new meters and 24-hour water supply at an adequate water pressure, the consumers will no longer need the tanks and pumps to cope. Presumably, they will save the marginal running costs in terms of electricity to fill up the tanks, maintenance, and tanks. This is part of the resources saved and considered as the economic benefits created by metering under the proposed program. It is shown in Figure 20.3 in the area of OC_0BQ_0 .

On the other hand, these customers currently pay a flat monthly fee of B 7 in 1998 prices with a zero marginal cost for additional water consumed. Once they are metered and facing a tariff schedule with a higher marginal tariff of P_1 , the quantity they consume would decrease from the current consumption of Q_0 to Q_1 . The reduction in consumption would result in a loss of economic benefits, which is measured by area Q_1ABQ_0 .

Therefore, with the program the total net economic benefits can be measured by the amount of the resources saved represented by the area of OC_0BQ_0 in excess of the economic loss in reduced consumption of Q_1ABQ_0 . These people represent approximately 15 percent of the total connected residents who obtain water from the IDAAN.

Figure 20.3: Demand for Water by Unmetered Customers Who Cope with Intermittent Supply Using Overhead Tanks without the Program

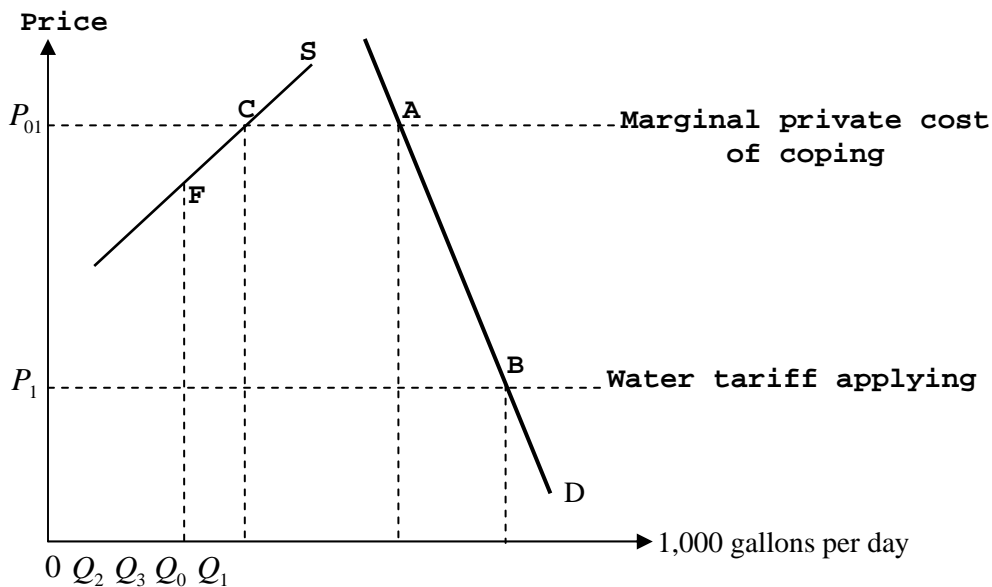


(c) Demand for Water by Unmetered Customers Not Coping with Overhead Tanks without the Program

The economic analysis for the consumers who are not able to cope with the intermittent water supply by using tanks is influenced by the alternative methods they employ to obtain water along with the associated costs. Figure 20.4 illustrates the program's economic benefits generated from supplying water to these customers. Although these people have water connection the quantity they receive is rationed so that they also have to purchase additional water from private vendors for at least part of their consumption.

In Figure 20.4, suppose that the total demand for water of this category (c) is Q_0 , of which the volume of water obtained via the IDAAN is Q_2 in the absence of the program. The quantity obtained from vendors or carrying it to the homes from standpipes is then represented by the volume $Q_0 - Q_2$. Of this amount we can show an amount $Q_0 - Q_3$ that is obtained by household carrying water from standpipes and an amount $Q_3 - Q_2$ representing purchase of water from vendors. For this quantity, they have to incur heavy coping costs of time and effort to bring water to their homes or pay the price of water charged by vendors. These coping costs are estimated at B4.5 and B4.4, respectively per 1,000 gallons of water. These coping costs are much higher than the fixed monthly water fees of B 7 that the IDAAN was charging residential consumers. The coping costs are also higher than the projected water tariff after privatization, including the proposed 10 percent price increase.

Figure 20.4: Demand for Water by Unmetered Customers Not Coping with Overhead Tanks without the Program



The above description can be illustrated in Figure 20.4. The economic benefits from the proposed program for this category of consumers are measured from three sources. First is the value placed on the additional consumption ($Q_1 - Q_0$) resulting from the reduced cost of obtaining water, Q_0ABQ_1 . Second is savings resulting from no longer having to obtain water from vendors, Q_2FCQ_3 .¹¹ Third is the gain measured in time savings resulting from not having to haul water from public taps. On the margin the value of the coping cost of self-hauling and the price paid to the vendors for the water will be equal. The amount of the gains depends upon the value of time spent by various households. This is represented by an area of Q_3CAQ_0 .¹² This group accounts for 9 percent of all connected residents customers.

Non-Revenue Water under the Existing System

This water is separated into the previous two categories. It consists of pilfered water and water lost to leakage.

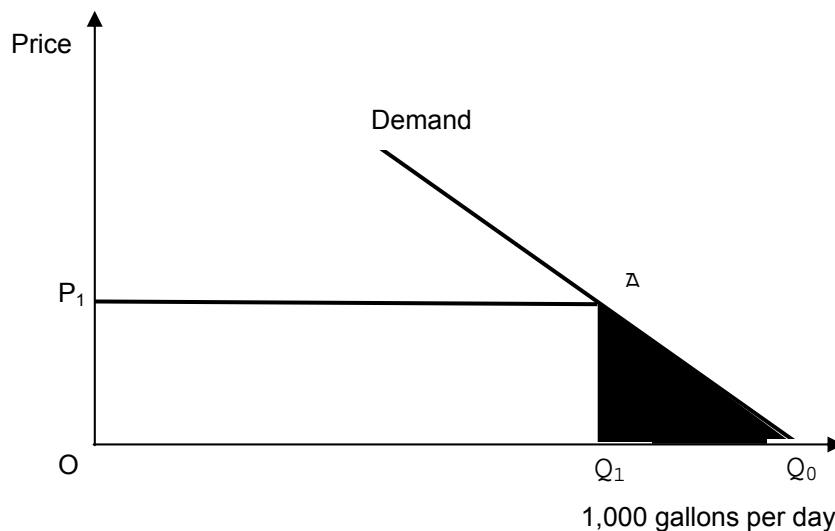
A large quantity of water in the existing system is pilfered through illegal connections by non-paying users. The program is expected to get these people to pay for the water they use. In response one would expect that these consumers will reduce the quantity of water they demand. This reduction in demand for non-paying water will release water that had some economic value to the demanders even though it was stolen. As shown in Figure 20.5, the proposed program would enhance administration capacity, improve monitoring, policing, and metering of the water system. The consequence with the volumetric tariff will decrease the quantity of water consumed from Q_0 under the “without program” scenario to Q_1 under the “with program”. The resulting economic loss associated with the reduction in the quantity demanded will be measured the triangle Q_0AQ_1 . However, the income loss to those who were previously pilfering the water is much larger. It is equal to their total loss in consumer surplus as a result of the anti-pilfering program introduced by the project, OP_1AQ_0 .

¹¹ It is assumed that vendors set the price of the water they sell at their marginal cost of supply.

¹² In this exercise, the annual value of time spent per household to obtain water in the absence of the program is assumed to be B 35.97 and the water hauled from public taps per household per year is 8,175 gallons.

Unlike pilfered water that actually has an economic value even though it does not generate revenue for the utility, the water leaking out of the distribution network does not generate any economic benefits. The program's leak detection component will retain more water for distribution to consumers and represents a saving equal to the reduction in the economic costs incurred by the utility to supply the water that leaks from the system.

Figure 20.5: Demand for Pilfered Water



The water savings from the decrease in consumption brought about by the increase in the tariff structure and the sharp reduction of unmetered connections are estimated to be approximately 15 billion gallons per year. The corresponding reduction in the utility's operating and maintenance costs provides a measure of the economic value of the resources saved. In the appraisal of the program, this is included in the reduction of operating costs of the utility.

The program will also reduce the raw water produced at the Mirshasaplant by 27 million gallons per day and the Hopaplant by 5 million gallons per day. The economic benefits

arising from these savings are the reduced economic costs of pumping raw water, estimated to be 15 percent of the total operating and maintenance costs.

20.5.3 Conversion Factors of Program Inputs

The previous section dealt with the incremental benefits of the program. This section considers the other side of the equation, the incremental costs of the program. The costs are simply the costs of resources used as a consequence of the implementation of the proposed program.

Before calculating the economic cost of the program's inputs, one must calculate the conversion factors for all the basic components of its investment and operating costs. These items are first divided into tradable goods (including equipment, machinery, cement, fuel, steel, and chemicals) and non-tradable goods (including freight, handling, and electricity). The economic cost and the conversion factors for each of these items are computed following the methodology developed in Chapters 10 and 11 for tradable and non-tradable goods and services, respectively. The conversion factors for different types of labor -- administrative, skilled, unskilled, and foreigners employed in the program are also calculated based on the supply price approach outlined in Chapter 12. The conversion factors of these basic tradable and non-tradable goods and services used in this program are summarized in Table 20.12.

A key economic adjustment that must be made is for the foreign exchange premium. This variable measures the difference between the market exchange rate and the economic opportunity cost of foreign exchange. This difference is due to the higher taxation of internationally traded goods and services. For Panama the value of the foreign exchange premium has been estimated to be 5.4 percent.

Table 20.12: Conversion Factors of the Basic Tradable and Non-tradable Goods and Services

Category	Conversion factor
Tradable Goods and Services	
Machinery and Equipment	0.915
Steel	0.931
Fuel	0.956
Chemicals	0.947
Cement	0.939
General Imported Goods	0.915
Non-Tradable Goods and Services	
Freight, handling and non-tradable materials:	
Handling	0.982
Freight	1.003
Non-Tradable materials	0.997
Sand	0.971
Electricity	1.018
Labor:	
Administrative	0.903
Skilled	0.970
Unskilled	1.000
Foreign consultants	0.726

After estimating the basic conversion factors, one can calculate the conversion factor of the program inputs or functions as the weighted average of the economic values of the basic components. The weights are given by the share of the cost of the basic items in the total cost. The aggregate conversion factors of program inputs or functions can be summarized in Table 20.13.

Table 20.13: Conversion Factors of the Program Inputs or Functions

Category	Conversion Factor
Investment Costs	
Supervision and management	0.885
Financial Administration	0.903
Execution and coordination	0.814
Direct Costs	
UFW reduction	0.921
Reserve tanks	0.950
Reinforcement and secondary network	0.948
Operating and Maintenance Expenses	
Personnel	0.971
Material	0.927
Marketing and administration	0.903
Cost saving from reduced bulk water purchase	1.017
Liquidation value of investment	0.896
Change in accounts payable	0.949

20.5.4 Economic Viability

An economic resource flow statement for the program is built in order to determine whether the proposed program is justified from the country's perspective. The gross economic benefits (or costs) of the additional (or reduced) consumption of water are estimated based on the methodology outlined in the previous section due to the enhanced administrative efficiency and the overall metering system. Estimates are not dependent on the specific tariffs used in the financial cash flow statement.

Estimates of the economic costs of resources used in the program are obtained by multiplying each line item in the incremental cash flow statement by the corresponding conversion factors as displayed in Table 20.13. The resulting economic statement of the program is presented in Table 20.14. The net economic NPV of the program discounted at the economic opportunity cost of capital for Panama of 9.3 percent is equal to about B10.4 million. This indicates that the proposed program would generate a higher economic benefit than the capital would have produced elsewhere in the country.

Up to this point we have not considered the possibility that if this water concession is awarded to a foreign owned company; it will likely result in an increased outflow of profits abroad. When there is an outflow of profits abroad that is more than the normal opportunity cost of foreign sourced funds there is an additional economic cost in terms of Panama's economic resources. The theoretical framework for the measurement of the economic cost of excess earnings being transferred abroad is discussed in Appendix 13A. In this case the outflow is far above the economic opportunity cost of the funds used by the program. The economic NPV of B10.4 million would be the outcome of the program only if all the "excess" profits were paid to residents of Panama including all investors of this program. However, even in this case, one would assume that there is indifference to a large transfer of income from water consumers to the private owners of the concession. Concern of this issue will be discussed later when evaluating the impact of foreign financing on the residents of Panama.

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**Table 20.14: Statement of Economic Benefits and Costs of the Program, Selected Years
(thousands of Balboas in 1998 prices)**

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2019	2020	2021	2022
Economic Benefits																						
Sales revenues																						
<i>Residential unmetered customers</i>																						
Metered customers w/o project	-	-	-	-	(649)	(669)	(690)	(710)	(710)	(710)	(710)	(710)	(710)	(710)	(710)	(710)	(710)	(710)	(710)	(710)	(710)	-
Unmetered customers with 24-hour supply w/o project	-	-	-	-	(530)	(548)	(567)	(585)	(585)	(585)	(585)	(585)	(585)	(585)	(585)	(585)	(585)	(585)	(585)	(585)	(585)	(585)
Unmetered customers with intermittent supply w/o project (cope with tanks)	-	-	-	-	2,946	3,047	3,150	3,249	3,249	3,249	3,249	3,249	3,249	3,249	3,249	3,249	3,249	3,249	3,249	3,249	3,249	3,249
Unmetered customers with intermittent supply w/o project (do not cope with tanks)	-	-	-	-	5,091	5,266	5,444	5,616	5,616	5,616	5,616	5,616	5,616	5,616	5,616	5,616	5,616	5,616	5,616	5,616	5,616	5,616
<i>Commercial and industrial customers</i>	-	-	-	-	(815)	(844)	(873)	(903)	(903)	(903)	(903)	(903)	(903)	(903)	(903)	(903)	(903)	(903)	(903)	(903)	(903)	-
<i>Government</i>	-	-	-	-	(262)	(266)	(271)	(275)	(275)	(275)	(275)	(275)	(275)	(275)	(275)	(275)	(275)	(275)	(275)	(275)	(275)	(275)
Total sales revenues	-	-	-	-	5,781	5,986	6,193	6,392	6,392	6,392	6,392	6,392	6,392	6,392	6,392	6,392	6,392	6,392	6,392	6,392	6,392	6,392
Non - Paying Customers	-	-	-	-	(4,429)	(4,570)	(4,714)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)	(4,854)
Cost saving from reduced bulk water purchase	-	-	-	-	588	588	588	588	588	588	588	588	588	588	588	588	588	588	588	588	588	588
Liquidation value	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3,930
Total Benefits	-	-	-	-	1,941	2,004	2,068	2,127	2,127	2,127	2,127	2,127	2,127	2,127	2,127	2,127	2,127	2,127	2,127	2,127	2,127	3,930
Economic Costs																						
Investment cost																						
Engineering and administration	918	1,161	918	93																		
Direct costs																						
<i>Panama - UFW reduction</i>	1,243	1,863	3,540	1,242																		
New physical infrastructure	609	1,218	2,041	304																		
System rehabilitation	1,497	2,993	5,015	748																		
<i>Colon - UFW reduction</i>	440	661	661	440																		
System rehabilitation	27	107	-	1																		
<i>Arraiján - UFW reduction</i>	299	447	447	299																		
New physical infrastructure	812	1,624	1,219	406																		
System rehabilitation	176	528	175	-																		
<i>Chorrera - UFW reduction</i>	314	392	472	315																		
New physical infrastructure	870	1,740	1,305	435																		
System rehabilitation	27	108	-	1																		
Concurrent costs	162	162	162	81																		
Contingency	739	1,300	1,595	437																		
Total investment cost	8,133	14,305	17,548	4,802																		
Operating costs																						
Personnel	-	-	-	-	(2,057)	(2,145)	(2,236)	(2,326)	(2,350)	(2,373)	(2,397)	(2,421)	(2,445)	(2,469)	(2,494)	(2,519)	(2,544)	(2,570)	(2,674)	(2,701)	(2,728)	-
Electricity	-	-	-	-	(1,395)	(1,440)	(1,485)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)	(1,530)
Chemicals	-	-	-	-	(220)	(227)	(235)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)	(242)
Materials	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marketing and administration	-	-	-	-	(920)	(930)	(939)	(948)	(958)	(967)	(977)	(987)	(997)	(1,007)	(1,017)	(1,027)	(1,037)	(1,047)	(1,090)	(1,101)	(1,112)	-
Excess Loss Because of Foreign Financing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Income tax	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Change in accounts payable	-	-	-	-	263	13	13	13	5	5	5	5	5	5	5	5	5	5	5	5	5	(272)
Change in cash balance	-	-	-	-	(395)	(20)	(21)	(21)	(11)	(11)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(13)	(13)	(13)	474
Total costs	8,133	14,305	17,548	4,802	(4,734)	(4,749)	(4,902)	(5,054)	(5,085)	(5,118)	(5,151)	(5,185)	(5,219)	(5,254)	(5,289)	(5,324)	(5,359)	(5,395)	(5,543)	(5,580)	(5,618)	201
Net Economic Benefits	(8,133)	(14,305)	(17,548)	(4,802)	6,675	6,754	6,970	7,180	7,211	7,244	7,278	7,312	7,346	7,380	7,415	7,450	7,486	7,522	7,669	7,707	7,745	3,729
NPV @ 9.3%	10,406																					

20.5.5 Economic Sensitivity Analysis

A sensitivity analysis is conducted to identify the variables that are most likely to affect the outcomes of the program from the economic perspective. These variables include change in water tariffs, time spent per day to get water from public taps, and coping costs per household for those using water tanks.

Water Tariff: The program's economic viability is sensitive to the likelihood of higher than anticipated change in water tariffs. As Table 20.15 shows, an increase in water tariffs of 20 percent would turn the economic NPV negative. This is due to the negative elasticity of demand for water with respect to price, which influences the size of the economic benefits (or losses) received by the consumers. Like the impact on the financial NPV, an increase in tariff is also influenced by additional revenues received. On the other hand, the economic NPV becomes greater if the level of the water tariff goes down.

Table 20.15: Sensitivity Test of Water Tariffs
(thousands of Balboas in 1998 Prices)

Changes in Water Tariffs	Economic NPV
-15%	53,658
-10%	45,766
-5%	37,495
0%	28,845
5%	19,815
10%	10,406
15%	618
20%	-9,549

Daily Time Spent to Fetch Water: The economic outcome of the program is quite sensitive to the amount of time spent per day to obtain water from the public taps in the current situation. Table 20.16 shows that, for example, a 50 percent increase in time spent per day from half an hour to three-quarters of an hour to fetch water would raise the economic NPV by more than B5.8 million.

Table 20.16: Sensitivity Test of Time Spent to Fetch Water from Public Standpipes
(thousands of Balboas in 1998 Prices)

Time Spent per Day to Get Water from Public Taps (hours)	Economic NPV
0.500	10,406
0.625	13,314
0.750	16,222
0.875	19,129
1.000	22,037
1.125	24,944

Savings in Coping Costs for Households with Water Tanks: Table 20.17 shows that the program's economic outcome is sensitive to changes in the estimates about the households' resource savings from the reduction in coping costs for those now using tanks. This is indeed the opportunity cost they had before and now saved after the program implementation. A divergence of 20 percent would increase the program's economic NPV by some B5.2 million.

Table 20.17: Sensitivity Test of Savings in Coping Costs for Households with Water Tanks
(thousands of Balboas in 1998 Prices)

Savings in coping Costs for Households	Economic NPV
-40%	85
-30%	2,665
-20%	5,246
-10%	7,826
0%	10,406
10%	12,987
20%	15,567
30%	18,147

20.6 Stakeholder Analysis

The third component of an integrated investment appraisal is the stakeholder impact analysis. A stakeholder analysis is employed to identify the segments of society that reap

the benefits of the program and which, if any, lose from the implementation of the program. The stakeholder analysis of a program builds on the identity that the sum of the financial value of the program item and all the externalities associated with the item in the program equals the economic value of the item. The externalities refer to the distortions such as taxes, tariffs, subsidies, and consumer or producer surplus.

On the basis of the identity, the present value of the net economic benefits over the life of the program discounted by the economic cost of capital should be equal to the present value of the financial net cash flow and the sum of the present values of all the externalities generated by the program, all discounted by the same economic opportunity cost of capital. This means that any programs will generate two types of net benefits: (a) financial net benefits, which accrue directly to those who have a financial interest in the program, and (b) distributive impacts or externalities, which are allocated to different segments of society. In this case, 9.3 percent is the economic opportunity cost of capital for Panama. To undertake the stakeholder analysis of the program, the projected incremental benefits and costs from the financial and economic appraisal are used.

20.6.1 Identification of Stakeholders and Externalities

To carry out the stakeholder analysis, the following steps are undertaken:

- Identifying the stakeholder impacts of the program item by item, by subtracting the total investment cash flow statement from the economic statement of benefits and costs,
- Calculating the present value of each line item's flow of distributive impacts,
- Allocating the present value of the externalities to the relevant groups in the economy.

The reconciliation between the financial flows, economic resource flows and distributional impacts of the proposed program, all discounted by 9.3% real, is presented in Table 20.18. To ensure that the analysis is performed in a consistent way, the

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economic NPV checks out, as it should, to be equal to the financial NPV plus the present value of all externalities (discounted by the same rate). Thus, B10.41 million as shown in Table 20.18 is equal to the sum of the financial NPV (B140.18 million) and the present value of all externalities (-B129.77 million) created by the program.

**Table 20.18: Present Value of Financial Cash Flows, Economic Resource Flows
and Externalities for the Program**
(thousands of Balboas in 1998 prices)

<u>Economic Benefits</u>	Financial NPV	PV of Externalities	PV of Fin+Ext	Economic NPV
Sales revenues				
<i>Residential unmetered customers</i>	2,244	-2,244	0	
<i>Residential metered customers</i>				
metered customers w/o project	19,466	-24,260	-4,795	-4,795
unmetered customers with 24-hour supply w/o project	14,284	-18,227	-3,944	-3,944
unmetered customers with intermittent supply w/o project (cope with tanks)	16,324	5,594	21,919	21,919
unmetered customers with intermittent supply w/o project (do not cope with tanks)	10,203	27,678	37,881	37,881
<i>Commercial & industrial customers</i>	3,400	-9,486	-6,087	-6,087
<i>Government</i>	1,662	-3,535	-1,873	-1,873
Total sales revenues	67,581	-24,480	43,101	43,101
Non - Paying Customers	74,479	-107,258	-32,779	-32,779
Cost sav. from red. bulk wat. purch.	3,973	69	4,042	4,042
Liquidation value -	523	-54	469	469
Total Benefits	146,557	-131,724	14,833	14,833
<u>Economic Costs</u>				
Investment cost -				
Engineering and administration	3,225	-405	2,820	2,820
Direct costs				
Panama - UFW reduction	7,451	-586	6,865	6,865
<i>New physical infrastructure</i>	3,866	-200	3,666	3,666
<i>System rehabilitation</i>	9,656	-646	9,011	9,011
Colon - UFW reduction	2,101	-165	1,936	1,936
<i>System rehabilitation</i>	136	-10	126	126
Arraijan - UFW reduction	1,423	-112	1,311	1,311
<i>New physical infrastructure</i>	3,846	-216	3,630	3,630
<i>System rehabilitation</i>	864	-58	806	806
Chorrera - UFW reduction	1,421	-112	1,309	1,309
<i>New physical infrastructure</i>	4,102	-212	3,889	3,889
<i>System rehabilitation</i>	136	-9	127	127
Concurrent costs	565	-55	509	509
Contingency	3,879	-279	3,601	3,601
Total investment cost	42,671	-3,065	39,606	39,606
Operating Costs				
Personnel	-16,820	486	-16,334	-16,334
Electricity	-10,145	-185	-10,329	-10,329
Chemicals	-1,723	91	-1,632	-1,632
Materials	0	0	0	0
Marketing & administration	-7,498	731	-6,767	-6,767
Excess Loss Because of Foreign Financing	0	0	0	0
Income tax liability	0	0	0	0
Change in accounts payable	203	-10	193	193
Change in cash balance	-310	0	-310	-310
Total costs	6,379	-1,952	4,426	4,426
Net Economic Benefits	140,178	-129,772	10,406	10,406

20.6.2 Distributive Impacts

The net impact of the proposed program on all the affected groups in the country, other than the investors of the program, is computed by adding up the positive and the negative externalities imposed on each of the groups. It is important to separate the affected stakeholders as well as quantify the magnitude of the burden imposed (or benefits received) by the proposed program on each group. The integrated appraisal employed for this program allows us to quantify the realized gains and losses distributed to each particular group of stakeholders.

The stakeholders of this program include the government, commercial and industrial customers, previously metered residential consumers, non-paying consumers without the program, and paying residential customers who are newly metered as part of the program. The last category is further broken down into customers with a 24-hour supply of water without the program, customers with an intermittent water supply without the program who cope by means of overhead tanks, and customers with an intermittent water supply who resort to public standpipes and water vendors. The distributive impacts of the program are presented in Table 20.19.

**Table 20.19: Distribution of the Program's Net Benefits among Stakeholders
(thousands of Balboas in 1998 Prices)**

Category	Externalities
Government	-1,568
Commercial and Industrial Customers	-9,486
Residential Customers:	
Metered customers before the program	-24,260
Unmetered customers with 24-hour supply before the program	-18,227
Unmetered customers who remain unmetered after the program	-2,244
Non-paying customers (before the program)	-107,258
Residential Customers who were unmetered with intermittent water prior to the program:	
Those cope using tanks	5,594
Those cope using public standpipes	27,678
Total	-129,772

The government would realize a net loss of about B1.57 million. On one hand, the government as the consumer of water would incur a loss of approximately B 3.52 million

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because of the reduction in water consumed as a result of the tariff increase. On the other hand, the government gains about B 3.06 million in import duties on machinery, equipment and other tradable goods in the construction phase, but loses B 1.11 million in duties because of the lower demand for tradable inputs brought about by the utility's improved operating efficiency.

The residential customers who were metered before the program and the commercial and industrial consumers also incur an economic loss related to the reduction in water consumed as a result of the 10% increase in tariff. Their losses are B 24.3 million and B 9.5 million, respectively. These two groups account for a total of 45% of all IDAAN's customers.

It is easy to see the program's distributive impact on metered customers graphically in Figure 20.1. The economic loss is represented by the area ABQ_0Q_1 . This is equal to the sum of the areas of EBQ_0Q_1 and ABE . Consumers' incremental financial outlay is $P_0P_1AE - EBQ_0Q_1$. The program's distributive impact on metered customers is measured by the net economic impact less the net financial impact. It is equal to the negative of the area $(ABE + P_0P_1AE)$.

Those residential customers who were not metered before the program but now received a 24-hour per day water supply and pay the new water tariff, will realize a loss of about B 18.2 million. This group represents 13 percent of the IDAAN's customers. Those residential customers who remain unmetered even after the program incur a loss of B 2.2 million because of the 10 percent increase in the monthly flat-fee. These represent 9 percent of the IDAAN's customers.

The clear losers from this program are those unregistered consumers who because of the program are detected and billed. They will lose about B 107.3 million. This can be seen in Figure 20.5. With the implementation of the program, the economic loss is given by the area Q_1AQ_0 . The incremental financial outlay by these water customers is $0P_1AQ_1$.

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Therefore the negative distributive impact on unregistered consumers is $(Q_1AQ_0 + OP_1AQ_1)$ or OP_1AQ_0 .

The major beneficiaries of the program are those residential consumers who previously received an intermittent water supply and incurred heavy coping costs to obtain water. Consumers who were able to cope by using tanks gain about B 5.6 million, because their savings of reduced coping costs exceeds the amount of economic losses incurred because of the reduction in their water consumption brought about by the tariff increase. This group makes up 15 percent of the IDAAN's customers. Furthermore, consumers who had to cope by means other than tanks gain about B 27.7 million. This gain reflects the value of coping costs saved because they no longer have to obtain water from the public taps or to buy water from private vendors, plus the value of the additional consumption resulting from a reduced cost of water. From this total, we need to subtract the amount they pay for water in the "with project" scenario. This group represents 9 percent of the IDAAN's total customer base.

Table 20.19 also shows that over 82.5 percent of the program's negative externalities will be incurred by IDAAN's current illegal and non-paying customers. This group will be hurt by the proposed restructuring and privatization. This program will likely have considerable political difficulties in being implemented, given the widespread negative impact it is likely to have, particularly on this group of customers.

20.6.3 Concerns with Current Non-Paying Customers

An important contribution of the stakeholder analysis is that it signals to the analyst some of the areas where the project may need to be adjusted in order to be sustainable. In this case a major problem is the fact that most of the people who now obtain their water either directly or indirectly from IDAAN will be adversely affected by the changes proposed by this project. In particular, more than 82.5% of the program's negative externalities that are incurred by IDAAN's current non-paying customers. This group is likely to pose

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tremendous political difficulties in carrying out the program successfully because some of these people are those that at some point were poor and were given free standpipe service.

From the financial analysis that if the program were unable to collect water tariffs from the currently non-paying customers, the program would still be able to generate a substantial amount of the financial NPV to the concessionaire's investment of B 40.1 million in 1998 prices, discounted at a real rate of 15%. The values of the ADSCR, ranging from 4.08 to 11.81 over the loan repaying period, are also much greater than the minimum rate of 1.4 being recommended for this type of project. In other words, the program is still going to be financially feasible and bankable.

Furthermore, the net economic NPV of the program discounted at the economic opportunity cost of capital for Panama of 9.3% is expected to increase to approximately B 43.19 million from B 10.41 million presented in the previous section. This is because the proposed program will no longer reduce the consumption of water by current non-paying customers. Now the economic NPV (B 43.19 million) is equal to the sum of the financial NPV (B 65.70 million) and the present value of all externalities (B -22.51 million) created by the program, all discounted by 9.3% real. The distributed impacts of the program on various stakeholders are then presented in Table 20.20.

Table 20.20: Distribution of the Modified Program's Net Benefits among Stakeholders (thousands of Balboas in 1998 Prices)

Category	Externalities
Government	-1,568
Commercial and Industrial Customers	-9,486
Residential Customers:	
Metered customers before the program	-24,260
Unmetered customers with 24-hour supply before the program	-18,227
Unmetered customers who remain unmetered after the program	-2,244
Residential Customers who were unmetered with intermittent water prior to the program:	
Those cope using tanks	5,594
Those cope using public standpipes	27,678
Total	-22,513

From this analysis we can see that by making this one change to the design of the project the results of the economic and stakeholder analysis is greatly improved while the results from the financial analysis remains significantly positive.

20.7 Risk Analysis

The fourth component of an integrated appraisal considers the nature of the risk associated with the program. A risk analysis is carried out in which the risk variables must be uncertain and significant in terms of its impact on the program outcomes. The variables with the significant effect are selected from the sensitivity analysis conducted in the previous sections. We then determine the range and probability distribution for each of the risk variables and specify the appropriate correlations between the variables. The output of the analysis is presented as a probability distribution of the important performance variables and their occurrence.

Table 20.21 presents the identified risk variables, and their corresponding ranges of values and probability distributions. In terms of relationship between the variables, a negative correlation of 0.80 has been modeled between commercial and technical losses. As metering is improved and commercial losses are reduced, an increase in the overall water pressure in the system will be required. This is likely to result in an increased rate of water leakage from the system.

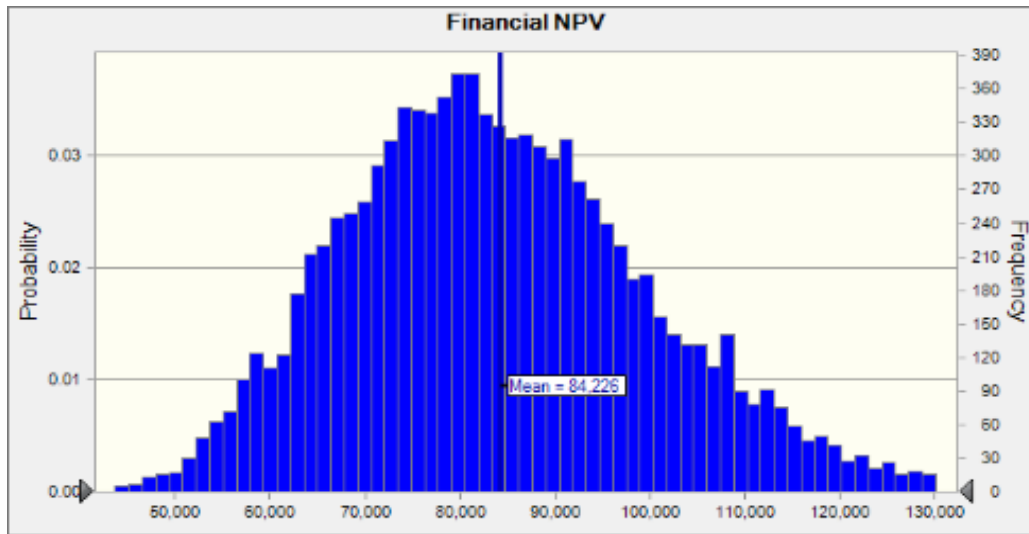
Table 20.21: Probability Distributions and Range Values for Risk Variables

Risk Variable	Base Value	Probability Distribution	Range Values	
			Minimum	Maximum
Commercial losses with program	15%	Triangular	5%	25%
Technical losses with program	10%	Triangular	5%	15%
Time per day to get water from public taps (hours)	0.5	Triangular	0.20	0.80
Divergence from savings in coping costs	0%	Triangular	-30%	30%
			Range	Probability
Investment cost overrun	0%	Step	-15% to -5%	15%
			-5% to 5%	75%
			5% to 25%	10%
Annual consumption per connection of residential metered customers (gallons)	155	Step	125 to 145	30%
			145 to 165	50%
			165 to 205	20%

Based on the underlying uncertainty surrounding each of the variables specified in Table 20.21, a Monte Carlo simulation is carried out over 10,000 trials. The risk analysis presented here was carried out under the assumption that the investors of this program are all residents of Panama. The rest of the assumptions and parameters used in the analysis refer to the base case scenario outlined in Sections 20.4.1, 20.5.2 and 20.5.3.

The results of the risk analysis displayed in Figure 20.6 shows that the expected value of the financial NPV discounted at 15% is B84.23 million, which is close to the value of the deterministic base case of B84.34 million. The risk analysis also confirms the program's robustness from the financial standpoint, with a mere 0.04% probability of the program outcome having a negative financial NPV.

Figure 20.6: Probability Distribution of the Financial NPV

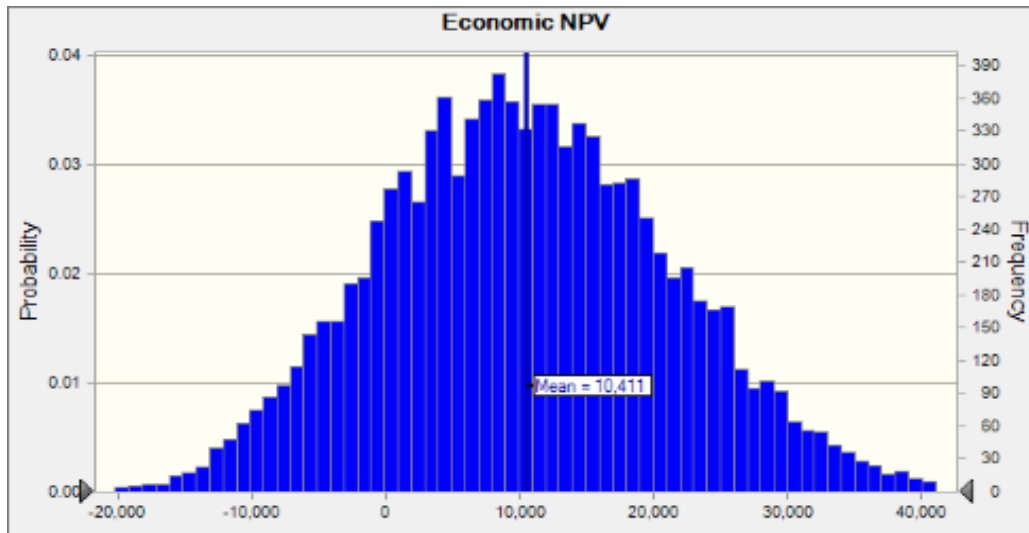


The rest of statistics of the simulation results are presented below:

Mean value	B 84,226 thousand
Median value	B 82,278 thousand
Standard deviation	B 16,371 thousand
Range: Minimum	B 43,731 thousand
Maximum	B 144,361 thousand

The expected value of the economic NPV is B10.411 million as shown in Figure 20.7, which is almost the same as the value of the deterministic base case of B10.406 million. The variation of the program outcomes is also smaller than that for the financial results. The probability of the project having a positive outcome turns out to be more than 82%.

Figure20.7:Probability Distribution of the Economic NPV

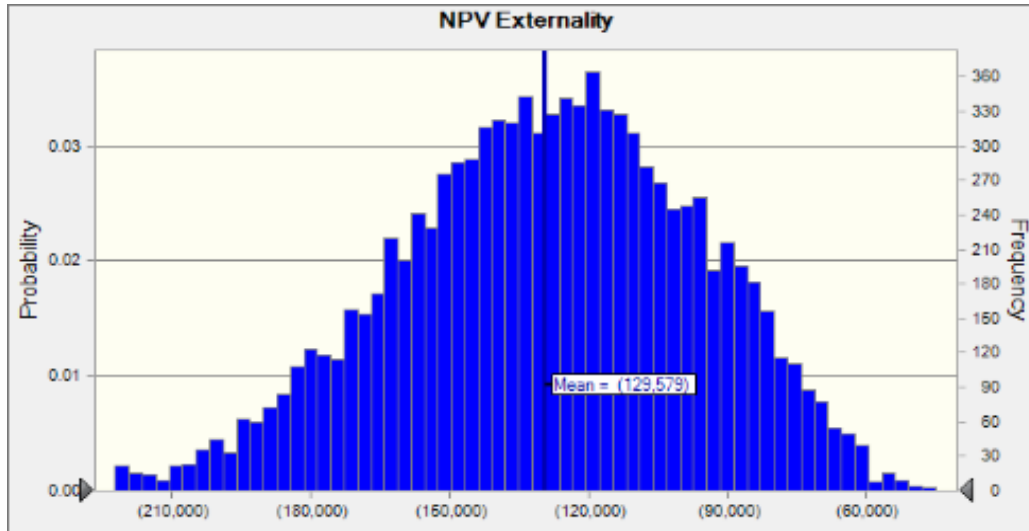


Some of other economic statistics resulting from the simulations are presented below.

Mean value	B 10,411 thousand
Median value	B 10,058 thousand
Standard deviation	B 10,941 thousand
Range: Minimum	- B 23,955 thousand
Maximum	B 50,741 thousand

The expected value of all the externalities is about – B 129.58 million, ranging from – B 250.74 million to – B 45.06 million as shown in Figure 20.8. This expected value is about the same as the deterministic case.

Figure 20.8: Probability Distribution of All the Externalities



20.8 The Economic Cost of Foreign Financing

The analysis we have carried out so far is based on the assumption that the program's investors are Panamanians. If the investors are foreigners, however, the economic outcome of the program can be quite different.

As water systems have become privatized around the world, the new private operators have frequently been multinational companies. These companies have great expertise in improving the operational efficiency of such public utilities. There is a need, however, to make sure that these improvements are obtained at a reasonable cost.

The net financial cash flow after debt financing accruing to the private equity holder of the program is presented in Table 20.3. It shows that under the proposed arrangements the financial NPV discounted at a 15 percent real is B 84.336 million. The last second row of Table 20.3 is also presented at the starting point of Table 20.22 below. One can calculate the proportion of the net financial cash flow that would be required to provide

the equity holders a real rate of return of 15 percent, (i.e., financial NPV = 0). It is 12.42% of the program's annual net cash flow that is required to provide the private enterprise with a net present value of zero at a 15 percent financial rate of return. This is illustrated in the third row of Table 20.22 for the first few years over the operating phase of the program.

**Table 20.22: Calculation of Excess Return to Foreign Investors
(thousands of Balboas in 1998 Prices)**

Category	1998	1999	2000	2001	2002	2003	2004	2005
Net cash flow after debt financing	-2,637	-4,619	-5,665	-1,554	25,671	20,279	21,740	22,729
% share of benefits to make NPV=0	-2,637	-4,619	-5,665	-1,554	3,188	2,519	2,700	2,823
Excess return to foreign investors					22,483	17,761	19,040	19,907
PV of excess return @9.3% = 142,109								

If the equity holders were domestic residents of Panama, then these excess profits (shown in the fourth row of Table 20.22) would represent a transfer from the water consumers to the private owners of the equity. It would be financially unjustified and, perhaps politically explosive, but in the aggregate it would not create an economic loss to Panama. On the other hand, if the private owners are foreign residents, the results are very different as the excess profits are estimated in the present value (at the economic discount rate of 9.3%) of about B 142,109 thousand, which is an economic cost to the country created by the generous terms of the private concession proposal. Foreigners now have a claim on this amount of country's resources.

If the excess profits are properly viewed as an economic cost, then the economic net present value of the program turns from being a positive value into a negative value. That is,

$$\begin{aligned}
 \text{Economic NPV} &= \text{Financial NPV} + \text{PV of All Externalities} \\
 &= \text{B } 140,178 + (- \text{B } 129,772 - \text{B } 142,109) \text{ thousand} \\
 &= - \text{B } 131,703 \text{ thousand}
 \end{aligned}$$

Moreover, it is unlikely that such an outcome is the objective of anyone associated with this proposed program. Table 20.23 shows the distributive impacts of the program on different stakeholders if the program is invested by a foreigner.

**Table 20.23: Distribution of Externalities among Stakeholders if Foreign Equity Holders
(thousands of Balboas in 1998 Prices)**

Category	Externalities
Government	-1,568
Commercial and Industrial Customers	-9,486
Residential Customers:	
Metered customers before the program	-24,260
Unmetered customers with 24-hour supply before the program	-18,227
Unmetered customers who remain unmetered after the program	-2,244
Non-paying customers before the program	-107,258
Residential Customers who were unmetered with intermittent water prior to the program:	
Those cope with tanks	5,594
Those cope with public standpipes	27,678
Economic Cost of Foreign Financing	-142,109
Total	-271,880

20.9 Conclusions

The proposed program shows how the results of the financial and economic appraisal of a program aimed at improving the overall efficiency of the water utility with no expansion of coverage can differ significantly when viewed from different perspectives.

The program to support the restructuring of the water and sewer utility is certain to have a substantial positive impact on the utility's financial performance. For an infusion of B 14.5 million of equity capital, the private operator is estimated to earn a financial NPV of B 84.3 million in 1998 prices using 15% real as the discount rate. Under the current proposal it is planned to increase tariffs by 10 percent above their current level following the program implementation.

The program is also expected to generate a significant amount of economic benefits as much as B 10.4 million to the total residents for society as a whole if the investment is

undertaken by Panamanians. The benefits are, however, mainly accrued to the investors. This will almost certainly be damaging to the country because the stakeholders of this program are paying the price and negatively affected by the program as much as B 111.3 million. The damage will even be much worse if the investment is due to foreign concessionaire because a substantial amount of the excess profits generated from the current proposal will be paid to foreigners. As a result, the simulations yield a huge negative economic cost to the country. Even though the program appears to be financially robust, considerable political risk is present that could bring about a very different financial outcome.

While the rate of return to the concessionaire becomes clear under the current proposal, it is unlikely to be politically sustainable. This is because that there is a significant amount of negative externalities, of which over 82.5 percent would be incurred by the current customers of water who are currently illegal and non-paying customers and who will be made worse off by the program. If the proposed restructuring is able to deliver the cost savings as planned, then a major reduction in the price of water is possible over time without hampering the financial performance of the utility. We found that the utility could reduce the water tariff structure for the program by up to around 40 percent and still it would remain financially viable. If this were to happen, the majority of the water customers could be made better off by the program. In such an event, the economic outcome would also become viable. Alternatively, if the current non-paying customers cannot be forced to pay their water tariffs due to social and political difficulty, the return to the concessionaire's investment is still well above its 15% real rate of opportunity cost and the financing arrangement is bankable. As a consequence, the stakeholder impacts are more balanced and the economic net benefits for society as a whole are even enhanced because the consumption of water by this group would not be negatively affected by the proposed program.

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