HANDBOOK ON ECONOMIC ANALYSIS OF INVESTMENT OPERATIONS

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Introduction

Background

1. The quality of economic analysis in the Staff Appraisal Reports (SARs) of Bank-financed projects has come under severe criticism in recent years. The Operations Evaluation Department (OED) has pointed to a gap between the estimates of economic rates of return at project appraisal and completion, unrealistic analysis of risk and uncertainty, and a failure of many projects to sustain benefit flows during execution. Two internal Bank reports[1] have concluded that the quality of economic analysis is below Bank standards in about one-third of SARs. Even outside the Bank, economists have expressed concern about the decline in methodological rigor, particularly in the application of the Little and Mirrlees/Squire and van der Tak approach to the economic analysis of projects.[2]

2. The two Bank reports considered the reason for the high incidence of SARs with poor economic analysis and concluded that the Bank provides poor incentives and overly complex guidelines on economic evaluation. Accordingly, both reports recommended simplifying the Bank guidelines for economic analysis. Specific recommendations included

- eliminating the inclusion of different public and private sector income (fiscal) weights and distributional (poverty) weights in the calculation of expected rate of return, but clearly indicating the fiscal and distributional implications of the project;
- using shadow prices selectively, depending on country circumstances and particularly on the severity and prevalence of distortions;
- continuing to use 10-12 percent as the Bank's standard discount rate. Country-specific opportunity cost of capital rates could be used on trial basis, but only if the Country Assistance Strategy fully justifies the rate;
- paying more attention to the financial aspects of the project, particularly as they bear on its implementation and sustainability;
- including environmental costs and benefits in economic analysis; and
- improving risk analysis in order to assess the cumulative probability of an unsatisfactory outcome.

3. This Handbook has been developed with these recommendations in mind. Its goals are (a) to provide staff with analytical tools that are solidly grounded in economic theory, yet practical and simple to use, and (b) to make the Bank's approach to the economic evaluation of projects more transparent—for clients, stakeholders, donors, and cofinanciers. The Handbook offers a set of usable tools that integrate financial, economic, and fiscal analysis and permit analysts and decision makers to look at a project from the perspective of various stakeholders, particularly the implementing agency, the fisc, and society in general. Because the Handbook is intended to be a practical guide to economic project evaluation, all of the techniques presented in it have been tried and applied in the field.

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[1] *Economic Analysis of Projects: Towards a Results-Oriented Approach to Evaluation* (1992); and *A Review of the Quality of Economic Analysis in Staff Appraisal Reports for Projects Approved in 1993* (1995).

[2] See, for example, Little and Mirrlees (1990).

Organization of the Handbook

4. The Handbook is divided into two parts: a main text and a Technical Appendix. The main text provides a set of tools for economic and risk analysis and discusses issues that commonly arise in the evaluation of projects in any sector. This part provides guidance on extending the financial analysis to view the project from the point of view of not only the implementing agency, but also the fisc, the beneficiaries, and society. The main audience of this part is the practitioner interested in the application of the techniques of project appraisal, but not necessarily in the theoretical underpinnings of the approach. Thus, it presumes that the person undertaking the analysis has been given a set of imputed prices that reflect the costs to society of the various inputs and outputs of the project (or "shadow" prices and conversion factors) in addition to the prices that the project entity faces. (For the practitioner who needs additional background, the Technical Appendix provides the guidance necessary to estimate social opportunity costs or shadow prices.)

5. Chapter 1 provides an overview of economic analysis—its purpose, the main questions it should answer, the main steps it should follow, and the minimum information that the analysis should convey to enable decision makers to make informed decisions. Chapter 2 focuses on the choice of numeraire and the problem of inflation. Chapter 3 discusses basic principles of economic analysis, such as the need to search for alternatives, the with- and without-project comparisons, and the problem of displacement of existing services. The theme of chapter 4 is "getting the flows right." The analyst's first task is to identify the costs and benefits of the project from the country's point of view. This chapter provides guidance on adjusting the monetary flows of these financial statements to assess the costs and benefits to society. Chapter 5 focuses on "getting the prices right." While financial analysis relies on prices faced by the project's implementing agency, economic analysis is based on opportunity costs to society. The chapter provides guidance on the main adjustments to market prices that must be made for the project to reflect benefits and costs from society's point of view, not just from the implementing agency's point of view.

6. One of the main differences between financial and economic analysis is the treatment of the project's impact on the environment. Unless this impact is directly reflected in the project's cash flows, financial analysis usually ignores it. Economic analysis, on the other hand, is incomplete if it does not take environmental impacts into account. Chapter 6 deals with the broad subject of "externalities," and in particular with the techniques for measuring the value of environmental impacts so that they can be taken into account in the economic analysis of projects.

7. For many types of projects—for example, those in the education and health sectors—the benefits are not readily measurable in monetary terms. Nevertheless, the general techniques of project analysis are applicable to such projects. Chapter 7 discusses techniques for assessing such projects, while chapters 8 and 9 focus respectively on the assessment of projects in education and in the health sector. These chapters specifically discuss the measurement of the benefits of projects in these sectors, as the measurement of costs is uniform across sectors.

8. Once the adjustments to financial analysis are made and the economic analysis is concluded, the analyst needs to assess the robustness of the project to changes in the basic assumptions. Ideally, the analyst looks not only at the effect on project outcomes of changes in the main assumptions—prices, and the physical relationships between inputs and outputs—but also at the institutional variables that affect project performance. Chapter 10 discusses the risk assessment tools that allow us to assess systematically the impact of changes in the economic variables and in the physical relationships of the project. Risk assessment allows the analyst to rethink the project design and make corrections to reduce risks, or to increase the project's net benefits to society.

9. Any good project entails gainers, and some projects entail losers. Financial analysis shows the gains to the project entity; economic analysis goes further and shows the gains to society and to specific groups in society. In particular, economic analysis should quantify the project's fiscal impact. Identifying gainers and losers and measuring the fiscal impact are important steps in assessing the project's sustainability, among other things. Chapter 11 uses two actual cases to demonstrate this use of the tools of economic analysis.

10. The second part of the Handbook, the Technical Appendix, provides a brief discussion of discounting techniques, but the bulk of the chapter is a presentation of the theoretical underpinnings of the approach for assessing social opportunity costs. The appendix is directed primarily to those charged with the estimation of shadow prices. The presentation relies solely on elementary algebra and geometry. It assumes that the reader is an economist, or at least is familiar with the basic concepts of supply, demand, and elasticities. The appendix applies the same basic approach to the calculation of all social opportunity costs, whether they are costs of material inputs, tradeable goods, nontradeable goods, exchange rate, capital, or labor. In addition to developing the basic theoretical concepts, the appendix also shows how these concepts were applied in actual case studies.

Chapter 1. An Overview of Economic Analysis

Purpose of Economic Analysis

1. The main purpose of project economic analysis is to help design and select projects that contribute to the welfare of a country. Economic analysis is most useful when used early in the project cycle, to catch bad projects and bad project components. If used at the end of the project cycle, economic analysis can only help in the decision of whether or not to proceed with a project. When used solely to calculate a single summary measure, such as the project's net present value (NPV) or economic rate of return (ERR), economic analysis serves only a very limited purpose.

2. The tools of economic analysis can help us answer various questions about the project's impact on the entity undertaking the project, on society, on the fisc, and on various stakeholders, and about the project's risks and sustainability. In particular, they can help us (a) decide whether the private or the public sector should undertake the project; (b) estimate the project's fiscal impact; (c) determine whether the arrangements for cost recovery are efficient and equitable; and (d) assess the project's potential environmental impact and contribution to poverty reduction. This Handbook provides a toolkit that helps answer these questions; it does not provide a recipe for every possible instance. The *procedure* set out in this Handbook is an iterative process that begins early in the project cycle and is used throughout it. This procedure works best when it uses all of the information available about the project, including the financial evaluation and the sources of divergence between financial and economic prices.

The Economic Setting

3. A project cannot be divorced from the context in which it takes place. The links between the project and the sector and the country strategy need to be established early in the presentation of the project. The key role of the policy and institutional framework also needs to be discussed. Research indicates that projects do better in environments with low distortions than in highly distorted environments.[1] One of the first questions analysts should ask is whether the sector and macro preconditions are satisfactory for the project. In particular, they should inquire whether there are key distortions that should be removed prior to project implementation to ensure project effectiveness. With projects increasingly stressing policy reform and institution building, project appraisal needs to include an evaluation of the project's policy and institutional components. The relationship of the project to the broader development objectives of the sector and of the country is an integral part of the economic justification of the project, and analysts should always ascertain that the project fits with the broader country and sector strategies. These aspects of the evaluation normally derive from the economic and sector work on which the project is based.

Rationale for Public Sector Involvement

4. Analysts should also examine whether the project properly belongs in the public sector or whether the country would be better served if the project were undertaken by the private sector. Although the tools of economic analysis can shed light on these questions, in this Handbook it is assumed that these questions have been answered satisfactorily. It is also assumed that there is good justification for public sector involvement in the project.

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[1] Kaufmann (1991).

Other Aspects of Project Analysis

5. A large part of project analysis, then, serves to establish a project's technical and institutional feasibility, its fit with the government's and Bank's strategies for the country and the sector, and the appropriateness of the economic context for the project, including the soundness of the country's public expenditure plans. Economic analysis is only one part of the overall analysis of the project; it takes for granted that the project is technically sound and its institutional arrangements will be effective during implementation. The purpose of this section is to give a general overview of the questions that good economic analysis of projects should ask and answer. The section can serve as a checklist for project analysts and a map for finding in the Handbook the tools that help answer those questions.

Fungibility

6. A final question that should be answered prior to undertaking a full appraisal of a project concerns the quality of the country's public expenditure program. Given that money is fungible, when the Bank finances a project, the borrowing government can use its own funds to finance another project. In a sense, then, the Bank is financing the project that the government would not have undertaken had it not had access to Bank financing. If the project that would not have been undertaken produces lower benefits than the project that the Bank finances, then the Bank has indirectly helped a country finance a less desirable project. For this reason, it is important to ensure, within the limits of practicality, that all the projects in the public investment programs of borrowing countries contribute to the country's development objectives.

The Questions that Economic Analysis Should Answer

What is the objective of the project ?

7. The first step in the economic analysis of a project is to define clearly the objective(s) that the project is trying to achieve. A clear definition of the objective is essential to reduce the number of alternatives considered, and to select the tools of analysis and the performance indicators. Is the project trying to achieve a narrow objective, such as improving the delivery of vaccines to a target population, or is it trying to achieve a broader objective, such as improving health status? If the former, then the analyst will only look at alternative ways of delivering vaccinations to a target population, and will judge the success of the project in terms of the vaccination coverage obtained. If the latter, then the analyst will look not only at alternative ways of delivering vaccinations but at alternative ways of reducing morbidity and prolonging the lives of the target population, and will judge the success of the project in terms of its impact on health status. The appropriate tool of analysis also depends on the breadth of the objective. For example, if the objective is to reduce the cost of vaccination, cost-benefit ratios might be adequate ways of comparing and selecting among interventions. If the objective is to improve health status, then the interventions need to be compared in terms of the impact on health status. If the objective is even broader—say, to increase a country's welfare—then the comparisons need to be done in terms on a common unit of measurement, usually a monetary measure. In short, a clear objective is essential to define the set of feasible alternatives for obtaining the desired result, and to select the tools to analyze the problem and the indicators of success.

What will happen if the project is undertaken? What if it is not?

8. One of the most fundamental questions concerns a counterfactual: What would the world look like without the project and what would it look like with the project? What will be the impact of the project on various groups in the society? In particular, what will be the impact of the project on the provision of goods and services in the private sector: Will the project add to the provision of

goods and services, or will it substitute for (displace) goods and services that would have been provided anyway? The difference between the situation with and without the project is the basis for assessing the incremental costs and benefits of the project. Both the financial and economic analysis of the project are predicated on the incremental net gains of the project, not on the before/after gains. Chapter 3 deals with this issue.

Is the project the best alternative?

9. A second important question concerns the examination of alternatives. Are there any plausible (mutually exclusive) alternatives to the project? Alternatives could involve, for example, different technical specifications, different policy or institutional reforms, different location, different beneficiaries, different financial arrangements, or differences in the scale or timing of the project. How would the costs and benefits of alternatives to achieve the same goal compare with those of the project? Comparison of alternatives helps planners choose the best way to accomplish their objectives. These questions are treated in chapter 3.

Are there any separable components? How good are they?

10. A closely related question concerns the separability of the components. Is the project one integrated package, or does it have separable components that could be undertaken, and justified, by themselves? If the project contains separable components, then each and every separable component must be justified as if it were the marginal component. Omitting a component whose presence cannot be justified always increases the project's net benefits. Unsatisfactory (separable) components should always be deleted from the project. Chapter 3 addresses these issues.

Winners and losers: Who enjoys the music? Who pays the piper?

11. A good project contributes to the country's economic output; hence it has the potential to make everyone better off. Nevertheless, normally not everyone benefits, and someone may lose. Moreover, groups that benefit from a project are not necessarily those that incur the costs of the project. Identifying those who will gain, those who will pay, and those who will lose gives the analyst insight into the incentives that various stakeholders have to see that the project is implemented as designed. It is especially important to identify the benefits accruing to and the costs borne by the "poor" or "very poor," as defined for the country by poverty assessments. Chapters 4 and 5 lay the foundations for identifying gainers and losers, and chapter 11 shows how the various tools can be used to help answer these questions.

What is the project's fiscal impact?

12. Given the importance of fiscal policy for overall macroeconomic stability, the fiscal impact of the project should always be analyzed. How and to what extent will the costs of the project be recovered from its beneficiaries? What changes in public expenditures and revenues will be attributable to the project? What will be the net effect for the central government and for local governments? Will the cost recovery arrangements affect the quantities demanded of the services provided by the project? Are these effects being properly taken into account in designing the project? What will be the effect of the cost recovery on the distribution of the benefits (gainers and losers)? Will the cost recovery arrangements contribute to the efficient use of the output from the project (and resources generally)? Is the nonrecovered portion factored into the analysis of fiscal impact? Chapters 3 and 4 lay the foundations for answering these questions, and chapter 11 puts it all together.

Is the project financially sustainable?

13. The financing of a project is often critical for its sustainability. Even a project with high benefits undergoes a lean period when it must be sustained by funds external to the project. The cash flow profile is often as important as the overall benefits. For these reasons, it is important to

know how the project is to be financed and who will provide the funds and on what terms. Is adequate financing available for the project? How will the financing arrangements affect the distribution of benefits and costs of the project? Is concessional foreign financing available only for the project, and not otherwise? These questions are dealt with in chapter 11 and, to a lesser degree, in chapters 4 and 5.

What is the project's environmental impact?

14. A very important difference between society's point of view and the private point of view concerns costs (or benefits) attributable to the project but not reflected in its cash flows. When these costs and benefits can be measured in monetary terms, they should be integrated into the economic analysis. In particular, the effects of the project on the environment, both negative (costs) and positive (benefits), should be taken into account and, if possible, quantified and assigned a monetary value. The impact of these external costs and benefits on specific groups within society, especially the poor, should be borne in mind. The external effects of projects are treated in chapter 6.

Techniques for assessment: Is the project worthwhile?

15. After taking into account all the costs and benefits of the project, the analyst needs to decide whether the project is worth undertaking. Costs and benefits should be quantified whenever reasonable estimates can be made. But given the present state of the art, it is not always feasible to quantify all benefits and costs, and various proxies or intermediate output may have to suffice. For projects whose benefits are measurable in monetary terms, the appropriate yardstick for judging whether the project is acceptable is the project's net present value. To be acceptable on economic grounds, a Bank-financed project must meet two conditions: (a) the expected net present value of the project must not be negative, and (b) the expected net present value of the project must be higher than or equal to the expected net present value of mutually acceptable project alternatives. For other projects, physical indicators of achievement in relation to costs (cost-effectiveness) are appropriate. In some other cases, a qualitative account of the expected net development impact might have to suffice. In all cases, however, the economic analysis should give a persuasive rationale for why the benefits of the project are expected to outweigh its costs, that is, why the net development impact of the project is expected to be positive. When quantitative analysis is carried out, economic and not market prices should be applied. Chapters 2–6 provide guidance on deciding which costs to take into account, valuing the flows, and finally comparing costs and benefits that occur at different times.

Is this a risky project?

16. Economic analysis of projects is necessarily based on uncertain future events and involves implicit or explicit probability judgments. The basic elements in the costs and benefit streams are seldom represented by a single value, but more often by a range of values with different likelihoods of occurring. It is desirable, therefore, to take into consideration the range of possible variations in the values of the basic elements and to reflect clearly the extent of the uncertainties attaching to the outcomes. At the very least, economic analysis should identify the critical variables that determine the outcome of the project, that is, the values that increase (decrease) the likelihood that the project will have the expected positive net development impact. These critical variables should emerge from the economic and risk analysis of the project. The analysis should also identify and reflect the likelihood that these variables may deviate significantly from their expected values, as well as the major factors affecting these deviations. The analysis should assess how likely such deviations are, singly and in combination, and identify the factors that are likely to create the greatest risks for the project. Finally, it should be explicit about actions taken to reduce these risks. If the analysis of risk is based on "switching values," it should identify the critical variables, individually and in

plausible combinations, and determine by how much they can change before the net development impact of the project becomes unfavorable. The evaluation of risk is the main theme of chapter 10.

The Process of Economic Analysis

17. After identifying with- and without-project situations, selecting the best of the alternatives considered, and dropping bad project components, the analyst prepares the financial analysis of the project. This step, which examines the net benefits to the project implementing agency, conveys important information about incentives. It helps assess whether the project would be of interest to the private sector. Once the financial analysis is complete, the analyst needs to adjust the flows and prices to reflect net benefits to society. As discussed in chapter 4, the analyst must get the flows right by removing all subsidies and taxes from the adjusted financial flows and taking into account the project's externalities, especially the environmental externalities. To assess the project's fiscal and financial sustainability, it is important to keep track of who receives or pays for the benefits and costs of the environmental externalities and for the implicit and explicit transfers (typically, income taxes, direct subsidies, and property taxes).

18. After correctly identifying the streams of costs and benefits, the analyst needs to price them right. Market prices seldom reflect the economic values of inputs and outputs, and adjustments need to be made. Chapter 5 explains that the main price adjustments include using "border" prices for all tradable goods and services and a "shadow" exchange rate to convert foreign to domestic currency. Information about the sources of divergence between border and market prices and between shadow and market exchange rates will help identify the groups that benefit from and pay for the differences.

19. The final price adjustments affect nontradeables. If nontradeables are a sizable part of project costs, their prices need to be adjusted to reflect opportunity costs to society. As chapter 5 discusses, labor is one of the most important nontradeables; this Handbook suggests that analysts use sensitivity analysis to determine whether the project's NPV turns negative when using an upper bound for the shadow price of labor (usually the market price). If it does not, then there is no need for further analysis. In many cases, especially in projects in health and education, volunteer labor is an important component. If project costs and sustainability are to be assessed correctly, such contributions need to be priced at their opportunity costs.

20. Next, the analyst needs to put this information together and identify sources of divergence between the financial and the economic analysis of the project. The sources of divergence convey very useful information that enables the analyst to answer a number of important questions. First, by identifying the *groups* that enjoy the benefits and pay for the costs of the project, this comparison helps identify the impact of the project on the main stakeholders and assess its sustainability. In particular, since taxes and subsidies are usually important sources of difference, this step is essential to assess the project's fiscal impact. Second, by identifying the *causes* of the differences between the financial and the economic evaluations, the analyst can tell whether the differences are market-induced or policy-induced. If they are policy-induced, the analyst needs to consider whether any types of policy changes would bring the economic and financial assessments closer to each other; in short, is the project timely, or might it be preferable to convince the authorities that what is needed is policy reform. Finally, the comparison also sheds light on the size and incidence of the environmental externalities that can be evaluated in monetary terms.

Transparency

21. It is important for the analysis to indicate the extent to which the success of the project depends on assumptions about macroeconomic, institutional, financial, behavioral, technical, and environmental variables, including assumptions about government implementation capacity, macroeconomic performance, and availability of local cost financing. The analysis should indicate

the key actions—by the government and the borrower—necessary for project success; these actions include implementing policy and procedural measures and ensuring the requisite degree of government commitment to and popular participation in the project. The analysis should include a comparison of project assumptions with the relevant historical values, and spell out the rationale for any differences. When all these points are made clear, the economic analysis provides an easily understandable and transparent product that policymakers can confidently factor into decision making.

Chapter 2. Numeraire, Price Level, and Real vs. Nominal Prices

Numeraire and Price Level

1. One of the earliest decisions that an analyst confronts is the choice of currency and price level in which to conduct the analysis. Financial analysis is usually conducted in the currency of the country undertaking the project and at prevailing market prices. Economic analysis can be conducted in domestic or foreign currency and at domestic or border price levels. The three most frequently used alternatives are

(a) domestic currency at the domestic price level,

(b) domestic currency at the border price level, and

(c) foreign currency at the border price level.

2. When the analysis is done in domestic currency at the domestic price level, the analyst is using the same price level and currency that a financial analyst in the borrowing country would use. In most countries, the domestic price level is the price level used to keep national accounts, the price level used by the government to reckon its taxes and expenditures, and the price level used by business. For purposes of economic analysis, when we use domestic currency at the domestic price level as numeraire, the prices of traded goods and services are taken at the "border price" and converted into domestic currency at a "shadow" exchange rate.[1] The prices of nontraded goods and services, such as cleaning services, are taken at their market prices. When the analysis is done in domestic currency at the border price level, the prices of all imports and exports, for example, are taken at the border price and converted into domestic currency at the prevailing market or official exchange rate. However, the prices of services, such as cleaning services are converted to their border price equivalent by means of a "conversion factor." If the analysis is done in foreign currency at the border price level, the prices of imports and exports remain in foreign currency, but the prices of such things as cleaning services are first converted to their border price equivalent by means of a conversion factor, and then to their foreign currency equivalent by means of the prevailing market or official exchange rate.

3. An example, summarized in table 2.1, will serve to illustrate the differences among these approaches. Suppose that we have two goods—an imported good, and a service (e.g., cleaning services) that can neither be imported nor exported, and whose market price reflects the true economic cost to the economy. Suppose that the imported good is subject to a tariff of 40 percent, making the cost of the good in the domestic market 40 percent higher than under conditions of free trade. Let's call the net-of-duty price the "border price." Assume, moreover, that the cost of foreign exchange to the economy is 14 percent higher than the official exchange rate. Finally, suppose that the official exchange rate with respect to the dollar is C$1.10:1. If we are calculating costs and benefits in domestic currency at the domestic price level, we take the border price of the imported good in foreign currency and convert it to domestic currency using the exchange rate that reflects the cost of foreign exchange to the economy (the "shadow exchange rate"), as shown in column 3 of table 2.1. If we are calculating costs and benefits in domestic currency at the border price level, we take the same border price and convert it to domestic currency using the official

[1] As discussed in chapter 4, border prices are either CIF or FOB prices suitably adjusted for internal transport costs and other costs, but net of taxes and subsidies.

exchange rate, as shown in column 4. If we are using the border price level in foreign currency, then we would not convert the price of the good into domestic currency, but would take the price in dollars, as shown in column 5. The price of cleaning services (and in general of all nontraded goods whose market prices reflect the true economic costs) would be converted as follows. If we are using domestic prices at the domestic price level, the price of cleaning services would be taken as given. If we are using domestic currency at the border price level, we would need to calculate the "border price" of cleaning services by using a conversion factor. In this case the appropriate conversion factor would be the ratio of the official to the shadow exchange rate, or 0.88. If the numeraire is foreign currency at the border price level, the "border price" in domestic currency would have to be further converted to dollars using the official exchange rate.

Table 2.1. Numerical Example in World and Domestic Prices

Category	*Domestic market price* (1)	*Border price* (2)	*Economic cost in domestic currency at domestic price level* (3)	*Economic cost in domestic currency at border price level* (4)	*Economic cost in foreign currency at border price level* (5)
Imported good	C$140	$100	C$125	C$110	$100
Cleaning service	C$50		C$50	C$44	$40
Memorandum items					
Official exchange rate	1.10				
Shadow exchange rate	1.25				
Conversion factor	0.88				

4. The choice of currency and price level is largely a matter of convenience that will have no impact on relative prices and on the decision to accept or reject a project (in table 2.1, for example, the price of the imported good relative to the price of cleaning services is 2.5:1 in all cases). As long as relative prices are unaffected, if the NPV is positive in one case, it will be positive in all cases. Moreover, the NPV measured in domestic currency at the domestic price level will differ from the NPV measured in domestic currency at the border price level by the ratio of the official exchange rate to the shadow exchange rate, that is, by the conversion factor shown in table 2.1. Therefore, one can quickly convert the NPV from one numeraire to another. The IRR remains the same, regardless of numeraire.

5. However, to integrate financial, fiscal, and economic analyses, to assess risk and sustainability, and to identify gainers and losers, the financial and economic analyses must be expressed in the same unit of account. When the financial analysis is done in one unit of account and the economic analysis in another, the differences between the financial and the economic values have no meaning. Because financial and fiscal analyses are generally done in domestic prices at the domestic price level, it is most convenient to do the economic analysis in the same unit of account. If we use the border price level for the economic analysis, the fiscal impact of the project would need to be calculated twice, first at the border price level and then at the domestic price level. Moreover, for the evaluation of projects whose benefits are nontradeable (for example, projects in education, health, and transportation), it is much easier to evaluate the benefits in domestic currency at the domestic price level than in some other numeraire. For these reasons, this Handbook uses domestic currency at the domestic price level for the numeraire.

Real Prices vs. Nominal Prices

6. Regardless of the numeraire and price level chosen, changes in the general price level that result from inflation should not affect the comparison of a project's costs and benefits for the purpose of calculating its contribution to society. For this reason, economic analyses are normally conducted using "real prices," and they distinguish whether the price changes anticipated during the life of a project are in *real* or in *nominal* terms.

7. *Real prices* do not reflect inflation. Market prices may rise for two reasons. First, they may rise because the general price level rises, i.e., because of inflation. If prices rise solely because of inflation, they rise in the same proportion. Market prices may also rise because of changes in the underlying conditions of supply and demand. For example, bad weather in Brazil may cause the world supply of coffee to fall and the price of coffee to rise. This would be a change in the *real* price of coffee. Real prices are usually expressed as of a certain date. For example, for a project in a country where the monetary unit is a peso, all prices may be denominated in terms of the purchasing power of 1994 pesos.

8. *Nominal prices* on the other hand, reflect any inflation or deflation occurring over time. The relationship among real prices, nominal prices, and inflation is given by the following formula:

$$P_n = [P_r \times (IPC/100)]$$

where P_n denotes the nominal price, P_r denotes the real price, and *IPC* is a price index. This index could be the consumer price index, the wholesale price index, or any other appropriate price index. In Bank work, we usually use the Manufacturing Unit Value Index (MUV)—a price index derived by weighting the price index of manufactures in each of the G5 countries by their respective shares of exports to the developing countries.

Constant Prices vs. Real Prices

9. The terms *constant prices* and *real prices* are often used interchangeably, but referring to real prices as constant prices is misleading. Real prices do not necessarily remain constant through time, but change in response to changes in the underlying conditions of demand and supply of the goods. As table 2.2 shows, both real and relative prices change over time. Normally, therefore, a single price estimate should not be given for an item throughout the life of the project. Whenever feasible and desirable in light of the available data, year-by-year changes in real prices should be incorporated in the cost and benefit streams. The difficulties involved in forecasting prices are not to be underestimated. The project analyst should consult with the relevant Country Operations Division regarding country- and project-specific estimates and assumptions. For other non-project-specific—or non-country-specific—forecasts, the Bank's quarterly publication *Commodity Markets and the Developing Countries* is the main source for price forecasts in Bank project analysis.

Table 2.2. Historical Prices of Petroleum, Coffee, and Copper
(constant 1990 US dollars)

Sector	*1990*	*1991*	*1992*	*1993*	*1994*
Petroleum ($/bbl)	21.2	17.0	16.3	14.6	13.9
Coffee ($/kg)	1.97	1.83	1.32	1.50	3.08
Copper ($/mt)	2,662	2,288	2,139	1,836	2,150

Real and Nominal Returns

10. Improperly accounting for the impact of inflation on the financial and economic performance of a potential project is one of the errors most frequently made in project evaluation.[2] Inflation should be treated explicitly in the economic evaluation of projects for the following reasons: (a) the amount borrowed to help finance a project depends on the rate of inflation; (b) the rate of inflation affects the project's financial rate of return through the explicit and implicit taxes collected by the government from the project and also through the implicit subsidy received by the project entity when the nominal interest rate on loans is lower than the rate of inflation; and (c) high rates of inflation may undermine the financial sustainability of projects through their deleterious effects on cash flows, especially if projects rely heavily on borrowed funds and nominal interest rates are high. These effects of inflation affect the *financial* and not the *economic* analysis of the project; that is to say, they do not affect the estimated economic net present value (NPV) of a project. Of course, if the project's financial viability is in jeopardy, its economic performance may suffer. Also, although inflation does not alter the net benefit streams of a project, it has fiscal implications: it alters the way project benefits are divided between the government and the project entity.[3] Thus, although economic analysis should always be conducted in real prices, it is customary to use nominal prices when setting up cash flows for the purpose of making a financing plan. Real-price cash flows are used to calculate financial or economic NPVs or IRRs and to facilitate the conduct of sensitivity, switching value, break-even, and pricing analyses.[4]

11. Setting up the cash flow of a project in nominal prices requires an inflation forecast. This is a difficult, if not impossible, task. There are no economic tools that allow us to forecast inflation as far into the future as required for the life of a typical project. Therefore, it is preferable to use real prices for both financial and economic analyses and then to conduct sensitivity analysis to estimate the impact of different inflation rates on the project's cash flows, its tax liabilities, and on the real value of its debt service.

12. As an illustration, consider the impact of inflation on debt service. Say that we have a $200 million loan disbursed in equal amounts over the course of two years with a 10 percent nominal interest rate. Assume that the loan is to be repaid in its entirety in the fifth year. The nominal cash flow from the point of view of the lender would look as follows:

Table 2.3. Nominal Cash Flows, 10 Percent Interest Rate, No Inflation

Year	0	1	2	3	4	5
Principal	-100	-100				
Interest		10	20	20	20	20
Amortization						200
Cash flow	-100	-90	20	20	20	220

2 See, for example, Jenkins and Harberger (1992), p. 6:1.

3 For example, inflation may increase the corporate income tax if the revaluation of assets lags behind inflation. In this case, inflation lowers depreciation allowances and hence raises taxable income.

4 For example, the calculation of average incremental cost as an approximation to long-run marginal cost in public utility pricing is normally carried out initially in constant prices and then adjusted for expected inflation.

The real return on this cash flow (and, of course, the real NPV of the loan) would depend on the inflation rate. If there is no inflation, the real return would be 10 percent (the present value of the flows, discounted at 10 percent would, of course, be zero). If inflation goes up to 5 percent per year, the real cash flow would be as follows:

Table 2.4. Real Cash Flows, 10 Percent Interest Rate, 5 Percent Inflation Rate

Year	0	1	2	3	4	5
Principal	-100.0	-95.2	0.0	0.0	0.0	0.0
Interest	0.0	9.5	18.1	17.3	16.5	15.7
Amortization	0.0	0.0	0.0	0.0	0.0	156.7
Cash flow	-100.0	-85.7	18.1	17.3	16.5	172.4

The real return on the loan from the lender's point of view would be only 5 percent, and its NPV (discounting the flows at 10 percent) would be minus $32 million. The $32 million would amount to an implicit transfer from the lender to the borrower. Inflation would have other effects as well. For example, the purchasing power of the second year disbursements would be less than expected, leaving a financing gap that would have to be filled from other sources. All of these effects can be calculated using a spreadsheet program and incorporating inflation rates as parameters. Using a similar procedure, we can assess the fiscal implications by conducting the analysis in real terms and then assuming various inflation rates.

Profitability of Individual Project Entities

13. Measures of financial profitability for individual project beneficiaries—measures such as are derived, for example, in farm budget analyses—should also be based on real prices. Because of taxes, subsidies, or other policies, the real prices to the enterprises, used in calculating the financial return, may not be the same as the prices used in measuring the economic return (this issue is discussed in Chapters 4 and 5). However, changes over time in these two sets of prices should be based on the same underlying market assumptions. Hence they should move in parallel unless there are strong indications that changes in policies affecting the margin between the prices relevant for the economic and financial analysis will result in divergent trends. In particular, it is generally inconsistent to calculate NPVs (or IRRs) on the basis of real prices, which are assumed to change, while calculating, for example, farm budget NPVs (or IRRs) on the basis of present prices, which are assumed to remain constant in real terms throughout the life of the project.

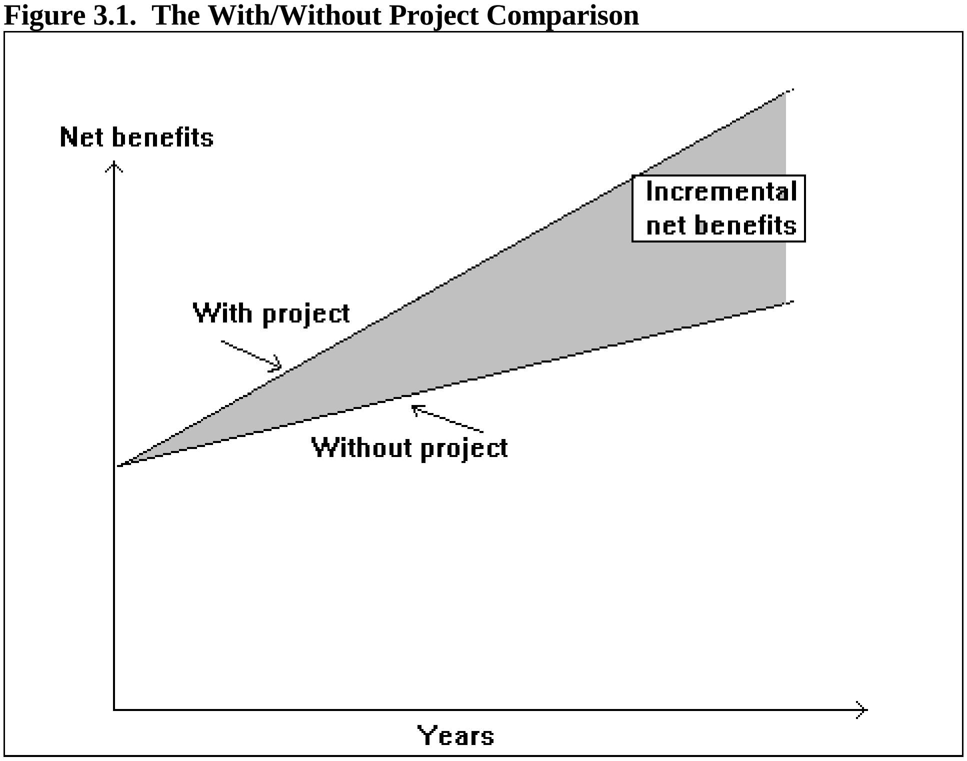
Chapter 3. Consideration of Alternatives

1. One of the most important steps in project evaluation is the consideration of alternatives throughout the project cycle, from identification through appraisal. Many important choices are made at an early stage, when alternatives are rejected or retained for more detailed study. The need to compare mutually exclusive options is one of the principal reasons for applying economic analysis from the early stages of the project cycle. The particular problem that a project is designed to solve may have many solutions, some of which may be optimal, not from an economic point of view, but from a technical point of view. Good economic analysis inquires whether the project can be expected to create more net benefits to the economy than any other known option for the use of the resources in question. The project design, therefore, should be compared with various other designs involving differences in such important aspects as the scale of the project, the choice of beneficiaries, the types of outputs and services, the production technology, location, starting date, and sequencing of components. The project should also be compared with the alternative of not doing it at all.

"With" and "Without" Comparisons

2. Whatever the nature of the project, its implementation reduces the supply of inputs and increases the supply of outputs available to the rest of the economy. Examining the difference between the availability of inputs and outputs with and without the project is the basic method of identifying project costs and benefits; it is not normally the same as a before/after comparison. The with/without comparison attempts to measure the incremental benefits arising from the project. The before/after comparison, by contrast, fails to account for changes in production that would occur without the project and thus leads to an erroneous statement of the benefit attributable to the project investment.

Figure 3.1. The With/Without Project Comparison



3. As figure 3.1 illustrates, a change in output can take place if production is already increasing (decreasing) and would continue to increase (decrease) even without the project. Thus, if production without the project were to increase at 3 percent per year and with the project at 5 percent per year, the project's contribution would be an increase of 2 percent per year. A before/after comparison would attribute the entire 5 percent growth in production, not just the incremental benefit, to the project. Of course, if production without the project were to remain stagnant and production with the project were to increase 5 percent per year, the before/after comparison would yield the same result as the with/without comparison. Box 3.1 shows a comparison of the costs and benefits of a highway rehabilitation project with and without the project.

Box 3.1: The With and Without Case: Viet Nam Highway Rehabilitation Project

After decades of war and economic stagnation, Viet Nam's deteriorated infrastructure threatens to hamper the country's economic recovery. It is estimated that the country needs to invest the equivalent of 3 percent of GDP per year over the next 10 to 15 years for the rehabilitation and modernization of the transport sector. The government has requested IDA assistance to rehabilitate the main highway network. The aims of the project are threefold: (a) to raise overall economic efficiency and support economic recovery by upgrading critical segments of the national highway network; (b) to transfer modern road technology to the relevant agencies through a program of technical assistance and training; and (c) to strengthen highway maintenance capacity by providing technical assistance and equipment.

The project has three main components: highway rehabilitation, improvements to ferry crossings, and technical assistance. IDA is financing $158.5 million of the total project cost of $176.0 million.

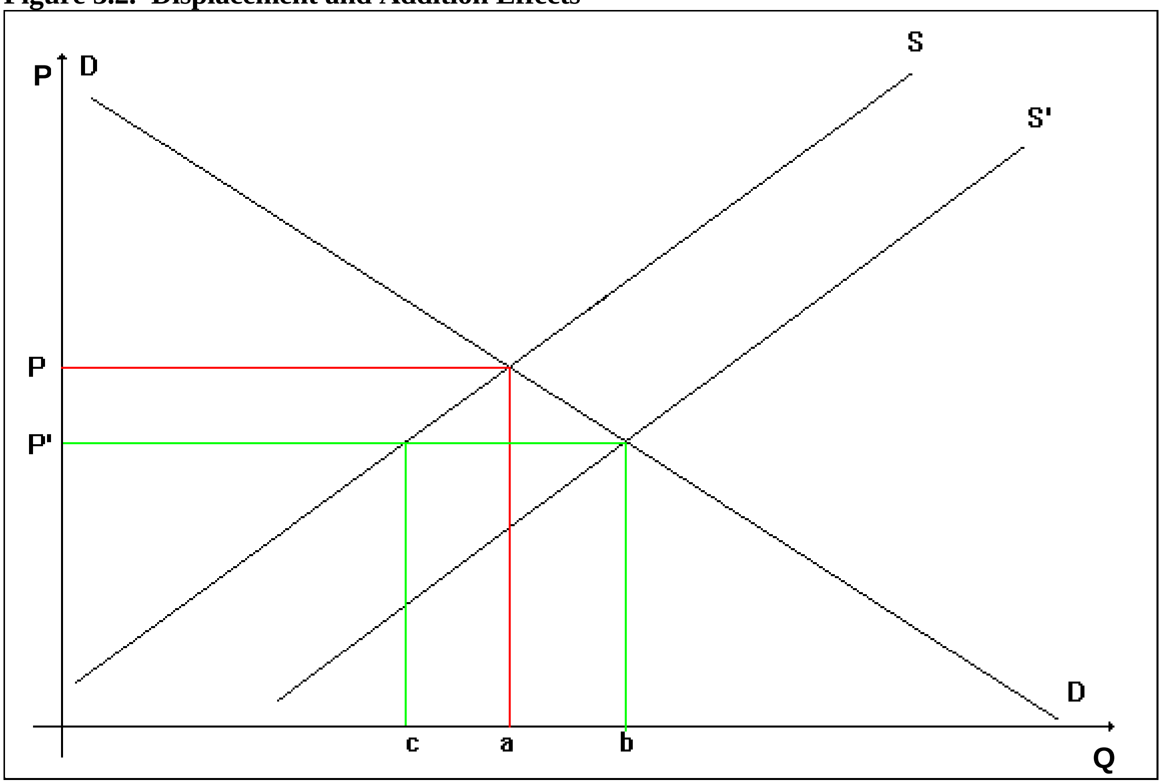
The table below illustrates the benefits of the highway rehabilitation component of the project. Similar analyses were conducted for the remaining components. The with/without project situations are compared in the analysis on the basis of highway maintenance costs and vehicle operation costs (VOC). The analysis takes into account project-induced changes in both surface conditions and vehicle speeds. The NPV of the project is US$533 million. The net cash flow is calculated for each of the 12 project years.

	Cost without project (US $ millions)		*Cost with project (US $ millions)*		*Benefit streams (US $ millions)*		
Year	*Maintenance (a)*	*Vehicle operation (b)*	*Construction maintenance (c)*	*Vehicle operation (d)*	*Construction cost savings (a-c)*	*VOC savings (b-d)*	*Net benefit flow*
1994	0.302	50.702	31.196	50.702	-30.894	0.000	-30.894
1995	0.353	63.144	14.449	63.144	-14.096	0.000	-14.096
1996	0.402	77.685	14.449	35.327	-14.047	42.358	28.311
1997	0.439	94.613	0.140	41.508	0.291	53.105	53.395
1998	0.491	114.600	0.151	48.970	0.341	65.630	65.970
1999	0.528	130.278	0.155	58.003	0.373	80.275	80.648
2000	0.573	166.845	0.159	68.900	0.414	97.945	98.358
2001	0.614	200.352	0.163	82.227	0.450	110.125	118.575
2002	0.666	241.962	0.172	98.392	0.494	143.570	144.064
2003	0.725	290.664	0.185	117.899	0.540	172.765	173.305
2004	0.765	345.234	0.205	142.454	0.561	202.780	203.341
2005	0.813	407.161	0.218	173.366	0.565	233.794	234.389

Source: Viet Nam--Highway Rehabilitation Project, Report No. 12025–VN

4. Sometimes a project competes with other projects and diverts demand away from existing projects. For example, a hospital may provide services not only to people who otherwise would not have had access to health care, but also to patients who would have used existing facilities. The benefits from the new hospital are overstated if the analyst counts as benefits the treatments received by all the patients visiting the hospital, rather than the incremental number of patients receiving treatment. This situation is illustrated in figure 3.2, where D is the demand for hospital services and S is the original supply of a good. The initial price is P and the initial quantity produced and consumed is a. The augmented supply after construction of a new facility is S' and the new price is P'. The project's total addition to capacity is cb, but the net increase in actual use of the service is ab, with a displacement of ac from the old facilities. The incremental benefit of the project is ab, even though the net addition to capacity is cb. If the project is a government-sponsored hospital, for example, and the initial supply was provided by the private sector, then the net benefits of the project would be overestimated if based on cb rather than on ab. Of course, the cost savings incurred in reducing the amount provided by the old facility also have to be taken into account.

Figure 3.2. Displacement and Addition Effects



Private Sector Counterfactual

5. An important consideration in the with/without the project comparison is the reaction of the private sector in the absence of the government project. In some cases the private sector would have stepped in and undertaken the project anyway. The costs and benefits of the government-provided good or service should then be compared with the costs and benefits of having the private sector provide the same goods and services. Although ultimately the decision to have government involvement in a particular project is a decision of policy and not necessarily of economics,

economic analysis can help decision makers by pinpointing the distribution of costs and benefits among the various stakeholders.

Separable Components

6. Sometimes a project consists of several interrelated subprojects or components. When the components are independent of each other, each component must be treated as if it were a separate project and the analyst must determine whether each component increases or decreases the project's total net present value. Any component that has a negative net present value should be dropped, even if the total net present value of all the components is positive. In other words, each separable component must justify itself as a marginal part of the overall project.

7. Suppose that a project provides three benefits, hydroelectric power, irrigation water, and recreational facilities. This project might appear at first to consist of three complementary and inseparable components. But if the water is needed early in the year for irrigation and only later in the year to meet peak demand for electricity, and if the tourist season occurs at the end of the year, the three uses might conflict with one another. For example, maximizing the use for electricity generation might result in an empty reservoir when the tourist season begins. If maximizing the net present value of the whole package entails reducing the efficiency of one component, then dropping one or more components might result in an overall package with a higher net present value.

8. Appraising such a project requires several steps. First, each separable component needs to be appraised independently. Second, each possible combination must be appraised. Finally, the entire project, comprising all of the separable components, must be appraised as a package. Thus, the hydroelectric component must be appraised separately, considering the most appropriate technology for generating electricity, disregarding its uses for irrigation or recreation. Similarly, the irrigation component must be appraised as an irrigation project, choosing the most appropriate design for irrigation and disregarding its potential use for electricity generation or recreation. Finally, the recreation component must also be appraised independently using the same general approach.

9. The second step would involve appraising three combinations, hydro-irrigation, hydro-recreation, irrigation-recreation. In each case, the most appropriate technology for the combination would be used, and the NPV of each combination would be assessed. The final step would be to evaluate the design that combines all three components. This design, as well, would be predicated on a technology that maximizes the NPV from the combined facilities. We would thus have seven alternatives: hydro, irrigation, recreation, hydro-irrigation, hydro-recreation, irrigation-recreation, and hydro-irrigation-recreation. The preferred alternative would be the one that yields the highest NPV. If there is a budget constraint, the preferred alternative would be the one that maximizes the NPV without exceeding the budget. [1]

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[1] This example is taken from Jenkins and Harberger (1992), pp.5:8-5:12.

Chapter 4. Getting the Flows Right: Identifying Costs and Benefits

1. The next step in economic analysis is to identify the project's costs and benefits. The projected *financial* revenues and costs are often a good starting point for identifying *economic* benefits and costs, but two types of adjustments are necessary. First, it is necessary to include (or exclude) some costs and benefits. Second, it is necessary to revalue inputs and outputs at their social opportunity costs. Financial analysis looks at the project from the perspective of the implementing agency: it identifies the project's net money flows to the implementing entity and assesses the entity's ability to meet its financial obligations and to finance future investments. Economic analysis, by contrast, looks at a project from the perspective of the entire country ("society") and measures the effects of the project on the economy as a whole. These different points of view require that analysts take into consideration different items when looking at the costs of a project, use different valuations for the items considered, and in some cases, even use different rates to discount the streams of costs and benefits.

2. In financial analysis we are interested in the items that entail monetary outlays. In economic analysis, we are interested in the *opportunity* costs for the country. Even if the project entity does not pay for the use of a resource, that does not mean that the resource is a free good. If a project diverts resources from other activities that produce goods or services, the value of what is given up represents an *opportunity* cost of the project to society. Many projects involve economic costs that do not necessarily involve a corresponding money flow from the project's financial account; for example, an adverse environmental effect that is not reflected in the project accounts may represent major economic costs. Likewise, a money payment made by the project entity—say the payment of a tax—is a financial but not an economic cost: it does not involve the use of resources, only a transfer from the project entity to the government. Finally, some inputs—say the services of volunteer workers—may be donated, entailing no money flows from the project entity. Such inputs also must be taken into account in estimating the economic cost of projects.

3. Another important difference between financial and economic analysis concerns the prices that the project entity uses to value the inputs and outputs. Financial analysis is based on the actual prices that the project entity pays for inputs and receives for outputs. The prices used for economic analysis are based on the opportunity costs to the country. The economic values of both inputs and outputs differ from their financial values because of market distortions created either by the government or by the private sector. Tariffs, export taxes and subsidies, excise and sales taxes, production subsidies, and quantitative restrictions are common distortions created by governments. Monopolies are a market phenomenon that can be created by either government or the private sector. Some market distortions are created by the public nature of the good or service. The values to society of common public services, such as clean water, transportation, road services, and electricity, are often significantly greater than the financial prices people are required to pay for them. It is such factors that create divergence between the financial and the economic prices for a project.

4. Economic and financial costs are always closely intertwined, but they rarely coincide. The divergence between financial and economic prices and flows shows the extent to which someone in society, other than the project entity, enjoys a benefit or pays a cost of the project. Sometimes such payments are in the form of explicit taxes and subsidies, as in a sales tax; sometimes they are implicit, as in price controls. The magnitudes and incidence of transfers are important pieces of information that shed light on the project's fiscal impact, on the distribution of its costs and

benefits, and hence on its likely opponents and supporters. By identifying the groups that benefit from the project and the groups that pay for its costs, the analyst can extract valuable information about the incentives that these groups have to see to it that the project is implemented as designed.

5. It is evident, then, that a thorough evaluation should summarize all of the relevant information about the project. To look at the project from the point of view of society as well as from that of the implementing agency, identify gainers and losers, and, ultimately, decide whether the project can be implemented and sustained, it is necessary to integrate the financial, fiscal, and economic analyses and identify the sources of the differences.

Cash Flow Analysis

6. Financial analysis of projects is based on *cash flow* analysis. For every period during the expected life of the project, the financial analyst estimates the cash likely to be generated by the project and subtracts the cash likely to be needed to sustain the project. The net cash flows result in the financial profile of the project. Because the financial evaluation of a project is based on cash flows, it omits some important items that appear in profit-and-loss statements. For example, depreciation and depletion charges are used in income statements and balance sheet accounting to arrive at an estimate of net profit. These concepts are imputed financial costs that do not entail cash outlays and consequently do not appear in either the financial or economic flows used to calculate net present values and economic rates of return.

Sunk Costs

7. For both financial and economic analysis, bygones are bygones. What matters are future costs and future benefits. Sunk costs are costs incurred in the past in connection with the proposed project. However ill-advised they may have been, such costs have already been incurred and can no longer be avoided. When analyzing a proposed project, sunk costs are ignored. Economic and financial analyses consider only future returns to future costs.

8. Ignoring sunk costs sometimes leads to seemingly paradoxical, but correct, results. If a considerable amount has already been spent on a project, the future returns to the costs of completing the project may be extremely high, even if the project should never have been undertaken. As a ridiculous extreme, let us postulate a poor project that needs only one dollar to be completed in order to realize any benefits at all. The returns to the last dollar may be extremely high, and the project should be completed even if it should never have been undertaken in the first place. But it is not valid to argue that a project must be completed just because much has already been spent on it. To save resources, it is preferable to stop a project midway whenever the expected future costs exceed the expected future benefits.

9. Although it may be more economical to stop a partially completed project than to finish it, this does not mean that a partially completed project can be closed at no cost. Closing a project is often costly: for example, partially completed contracts may have to be canceled and a penalty incurred. Such costs have to be taken into account in deciding whether or not to close the project. Similarly, the cash flow of a project should show some liquidation value at the “end” of the project, and this liquidation value should be counted as a benefit. Sometimes, to focus attention on the years for which the information is more reliable, it is useful to use the estimated liquidation value of a project as of a certain year.

Interest Payments and Repayment of Principal

10. Financial costs are an important component of a firm’s income statement. Debt service—the payment of interest and the repayment of principal—entails cash outlays, but is nevertheless omitted from economic and financial analysis because in both cases what matters is assessing the quality of the project independently of its financing mode. Another reason for excluding debt

service from economic analysis is that debt service does not entail a *use* of resources, but only a *transfer* of resources from the payer to the payee. Gittinger states the rationale very clearly:

> From the standpoint of the farmer [who receives a loan], receipt of a loan increases the production resources he has available; payment of interest and repayment of principal reduce them. But from the standpoint of the economy, things look different. Does the loan reduce the national income available? No, it merely *transfers* the control over resources from the lender to the borrower.... A loan represents the transfer of a claim to real resources from the lender to the borrower. When the borrower pays interest or repays the principal, he is transferring the claim to the real resources back to the lender—but neither the loan nor the repayment represents, in itself, *use* of the resources (Gittinger, 1982b, p. 52).

Interest during Construction

11. Sometimes lending institutions "capitalize" the interest during construction; that is, they add the value of interest during construction to the principal of the loan and do not require any interest payments until the project begins to generate income. Whether the interest is capitalized or not, its treatment for purposes of economic analysis is the same: interest during construction is still a transfer and is omitted from the economic accounts.

Physical Contingencies

12. Physical contingencies represent expected real costs and, unlike price contingencies, are included in project economic costs in project economic analysis. Physical contingencies may be "allocated" to specific items of cost, or they may be "unallocated"—that is, not attributable to expected cost increases for any specific item in the project costs.

Transfer Payments

13. Some payments that appear in the cost streams of financial analysis do not represent economic costs, but merely a transfer of the control over resources from one group in society to another group. For example, taxes and subsidies are transfer payments, not economic costs. The term "direct transfer payments" is used to identify payments that show up directly in the project accounts but that do not affect national income. Direct transfer payments—which include income taxes, property taxes, and subsidies—redistribute national income and generally affect the government treasury, positively or negatively. When looking at the project from the point of view of the project entity, taxes and subsidies affect the benefits and costs of the project, but when looking at the project from society's viewpoint, a tax for the project entity is an income for the government and a subsidy for the entity is a cost to the government. The flows net out. Should taxes and subsidies be disregarded? Not at all. Transfer payments affect the distribution of project costs and benefits and hence are important to assess who gains and who loses from the project. If taxes and subsidies render a project unfeasible from the point of view of the project entity, they are important in assessing project sustainability. A complete profile of the project should identify not only the amounts involved in taxes and subsidies but also the groups that enjoy the benefits and bear the costs. Usually, the government collects the taxes and pays the subsidies. In these cases, the difference between the financial and the economic analysis accounts for a major portion of the fiscal impact of the project.

Taxes vs. User Charges

14. Some care must be exercised in identifying taxes. Not all charges levied by governments are transfer payments; some are user charges levied in exchange for goods sold or services rendered. Water charges paid to a government agency, for example, are a payment by farmers to

the irrigation authority in exchange for the use of water. Whether a government levy is a payment for goods and services or a tax depends on whether the levy is directly associated with the purchase of a good or a service and accurately reflects the real resource flows associated with the use of the service. For example, irrigation charges frequently do not cover the true cost of supplying the service; thus, while they *indicate* a real resource flow as opposed to a pure transfer payment, the real economic cost would be better measured by estimating the long-run marginal cost of supplying the water and showing the difference as a subsidy to water users.

Subsidies

15. Subsidies are taxes in reverse and for purposes of economic analysis should be removed from the receipts of the projects. From society's point of view, subsidies are transfers that shift control over resources from the giver to the recipient, but they do not represent a use of resources. The resources needed to produce an input (or import it from abroad) represent the input's true cost to society. For this reason, economic analysis uses the full cost of goods, not the subsidized price.

Donations and Contributions in Kind

16. In some cases, the project entity receives goods and services free of charge. For example, in education projects it is common to have parents and volunteers perform essential services for schools. These services are rendered free of charge, but nevertheless they represent a true cost to the parents and volunteers and to the economy. In some other cases, the project may benefit from donations in kind. For example, hospitals may receive costly medical equipment as gifts from the private sector or NGOs. When evaluating projects from society's viewpoint, it is important to include these items. It is customary to impute a value to the goods and services so rendered by valuing them at their market price as a first approximation to their economic cost. The next chapter will deal with the valuation problems in more detail.

The China Agricultural Support Services Project: An Example

17. The China Agricultural Support Services Project (11147-CHA) illustrates some of these concepts. The objective of the project was to strengthen the institutions that provide support services to farmers, thus increasing the productivity and intensity of crop and livestock production. The project consisted of seven major components: agricultural management and information, extension, seed supply, livestock, animal and plant quarantine, quality control, and project management services. The total project cost was $238.3 million (1992 prices and exchange rate). Central, provincial, prefecture, municipal, and county governments would finance 52 percent, increasing public sector expenditures by $123.3 million. The remaining 48 percent would be financed by an IDA credit.

18. Farmers would be charged fully for services rendered through increased tax revenues and service fees. The incremental net income, imputed values for family labor, management services, return to own capital, taxes, and charges were estimated according to the adoption rates for two technologies (improving the existing technology or adopting new technology) and according to the incremental production under each of the three scenarios. Scenario I presented an adoption rate of 45 percent for existing technology and 5 percent for new technology; scenario II, 50 percent for existing and 20 percent for new; and scenario III, 50 percent for existing and 30 percent for new. The analysis was extended over the project's 20-year life using a discount rate of 12 percent. Project costs under scenario I were 820 million yuen and project charges (taxes) were 214 million yuan, resulting in a cost recovery index of 26.1 percent.

Table 4.1. Agricultural Support Services Project: Analysis of Fiscal Impact
(thousand yuan, NPV discounted at 12%)

Category	*Society*	*Government*	*Farmers*
Income	2,446,975		2,446,975
Costs			
Family labor	(971,757)		(971,757)
Management services	(244,697)		(244,697)
Returns to own capital	(122,349)		(122,349)
Contingencies	(244,697)		(244,697)
Taxes		213,758	(213,758)
Project costs	(819,993)	(819,993)	
Net benefits	43,482	(606,235)	649,717

19. Table 4.1 shows the estimated present value of the income, costs, and taxes under scenario I. Farmers receive the total income on the project, Y2.4 billion. Family labor, management services, imputed return on own capital, and contingencies are costs borne by farmers. In addition, farmers incur a tax liability of Y214 million, which, from the farmer's viewpoint is a cost and from the government's viewpoint an income. From society's viewpoint the transaction is a transfer that nets out and hence is not included in the project costs. Finally, the project's nonrecurrent costs, Y820 million, are borne by the government. Farmers increase their income by Y650 million, and society as a whole enjoys an income increase of about Y43 million. The fiscal cost of the project is Y606 million.

20. Presenting an integrated view of the financial, fiscal, and economic analyses along the lines of table 4.1 has major advantages. First, it shows why economic and financial analyses differ. In this case, the government is absorbing a major share of the costs and making the project even more attractive to farmers. Second, it clearly shows the fiscal impact of the project. Third, it provides an insight into the incentives that each of the stakeholders has to see the project through. In this case, the farmers are likely to be solidly behind the project, as they benefit handsomely. The government is also likely to support the project, as it wins farmer support. The same analysis done annually would show that the government bears project costs up front. Once the costs are incurred, the project is likely to be sustainable.

Externalities

21. A project may have a negative (or positive) impact on specific groups in society without the project entity incurring a corresponding monetary cost (or enjoying a monetary benefit). For example, an irrigation project may lead to reduced fish catch. The reduction in fish catch would represent a cost to society that would be borne by fishermen, yet it would not be reflected necessarily in the monetary flows of the project entity. These external effects, known as "externalities," need to be considered when adjusting financial flows to reflect economic costs. If the cost is measurable in monetary terms, we would gain an important insight into the incentives that fishermen would have to oppose the project. Chapter 6 treats environmental externalities in more detail.

Consumer Surplus

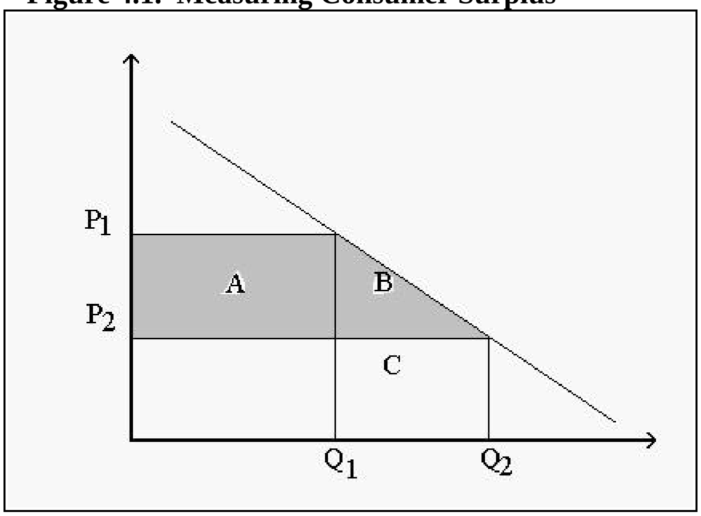
22. In some cases, a project may not only increase output but also reduce the price of the output to consumers. Output price changes typically (but not only) occur in power, water,

sanitation, and telecommunications projects. When a project lowers the price of the project's output, more consumers have access to the same product and the old consumers pay a lower price for the same product. Valuing the benefits at the new, lower price understates the project's contribution to society's welfare. If the benefits of the project are equated with the new quantity valued at the new price, the estimate of benefits ignores *consumer surplus*: the difference between what consumers are prepared to pay for a product and what they actually pay. In principle, this increase in consumer surplus should be treated as part of the benefits of the project.[1]

Measuring Consumer Surplus

23. Measuring consumer surplus is straightforward under certain simplifying assumptions. Consider a project that lowers the price of a product from P_1 to P_2. As a result of the lower price, the quantity demanded rises from Q_1 to Q_2, as figure 4.1 shows. Consumer surplus is the sum of areas A and B. Area A is what consumers save from the price drop and is equal to the difference in price times the quantity sold at the old price.

Figure 4.1. Measuring Consumer Surplus



24. In some cases, the savings that accrue to consumers (area A in figure 4.1) also represent a loss to producers. For example, take a hydroelectric project that reduces the cost of generating electricity and increases the amount of electricity available to the country. As a result of the project, the domestic price of electricity falls from P_1 to P_2. The original consumers save an amount equal to the area A. But this savings is compensated for by a corresponding loss of revenues for the electricity company. There is no net benefit to society from the savings thus obtained: the consumer's gain is the electric company's loss. The net benefit to society, therefore, is only the area B. Area A would also have been a net gain to the country if, say, the electricity had been imported and the project had consisted in substituting domestic for imported energy. In this case the gain to society would have been the sum of the two areas A and B.

25. Justifying a project on the basis of consumer surplus, however, presents practical difficulties because consumer surplus is a benefit that accrues to the consumer without a

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[1] There may also be a gain in consumer surplus without any decline in price. If supply is rationed at a price below what consumers would be willing to pay, an increase in supply at the same controlled price involves a gain in consumer surplus over and above what consumers actually pay for the increase. This may be particularly significant for public utility projects.

corresponding benefit to the producer. Thus, although a project may have a high NPV if consumer surplus is included, it may not be sustainable because the implementing agency will not partake of these benefits.

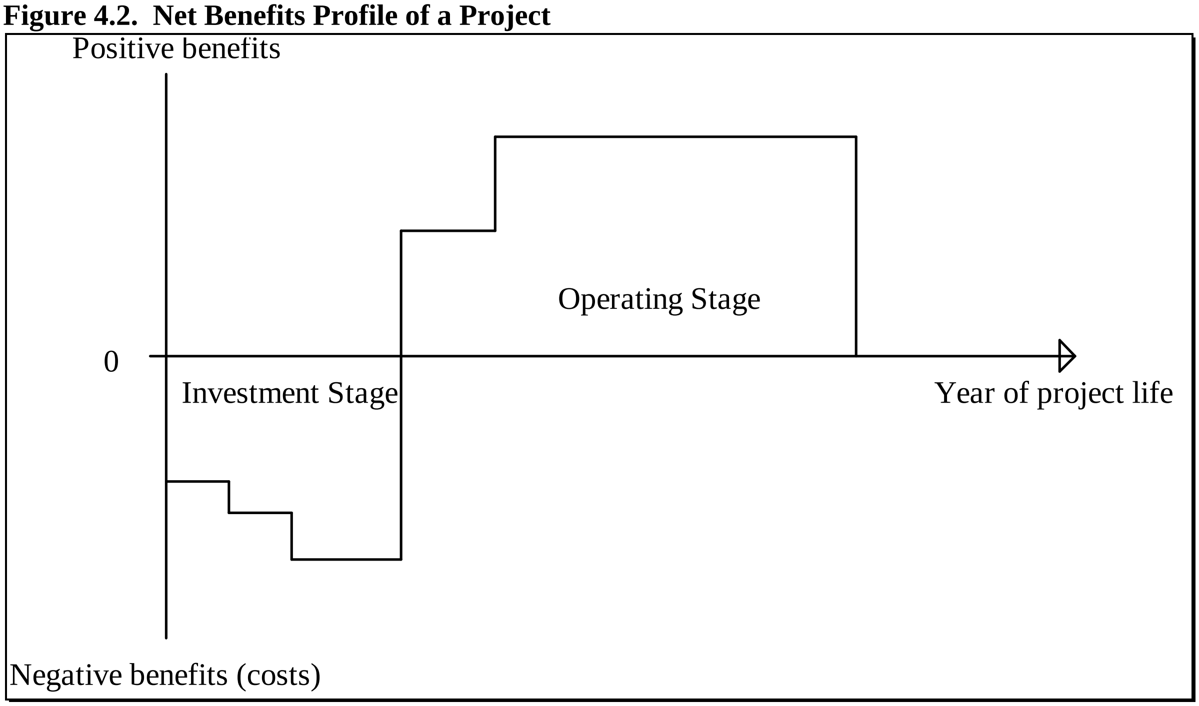
26. If the project entails a decrease in the price of the product and its NPV is positive even without taking into account consumer surplus, then adding consumer surplus to the benefits only increases the NPV of an already acceptable project. If, on the other hand, the project's NPV is negative, adding consumer surplus to the benefits might render the NPV positive. Relying on consumer surplus to justify such a project requires that analysts pay special attention to the project's financial viability. The project's economic viability will be undermined if financial viability is not ensured, and expenditures for operations and maintenance will inevitably suffer. For projects that are justified because of consumer surplus, then, analysts must show explicitly (a) the NPV with and without consumer surplus; (b) the amount of the financial shortfall and the source of funds to finance it; and (c) the sustainability of the arrangement.

27. If the project entails an increase in the price of the output (and hence a loss of consumer surplus), then, to avoid overestimating the NPV, the analyst should measure the loss and incorporate it into the economic analysis. The implications for the quantity demanded of project output must be explicitly stated and convincingly linked to relevant supporting evidence. Moreover, the realism and mutual consistency of the demand forecast and the projected level of the price of the output should be evaluated.

Net Benefits Profile

28. A project's financial and economic cash flows can be illustrated by plotting its net benefits on the vertical axis and time on the horizontal axis, as in figure 4.2. Usually, the net benefits profile is negative in the initial stages of a project's life, when the costs of getting the project started are incurred, and positive thereafter, when the benefits exceed the costs. Some projects may have negative net benefits during the middle of their lives if additional investments are necessary to keep them going.

Figure 4.2. Net Benefits Profile of a Project



Chapter 5. Getting the Prices Right: Market Prices vs. Economic Costs

1. Financial costs and benefits are valued at the prices that the project entity is expected to pay for them. Usually these are prices set by the market, although in some cases they may be controlled by government. However, these prices do not necessarily reflect economic costs to society. The economic values of both inputs and outputs may differ from their financial values because of market distortions created by either the government or the private sector. Tariffs, export taxes and subsidies, excise and sales taxes, production subsidies, and quantitative restrictions are common distortions created by governments. Monopolies are a market phenomenon that can be created by either private or public sector actions. Some market distortions are created by the nature of the good or service: the values to society of common public services, such as clean water, transportation, road services, and electricity, are often significantly greater than the financial prices people are required to pay for them. A project that sells electricity below its economic cost is implicitly subsidizing the users of the service. Similarly, a project that employs labor at a wage rate that is higher than labor's economic cost is implicitly subsidizing labor. The differences between financial and economic prices are rents that accrue to some group in the society and convey important information about the distribution of costs and benefits.

Valuation of Inputs and Outputs

2. In economies where distortions are few, market prices provide a reasonably good approximation of the opportunity costs of inputs and outputs. In economies characterized by price distortions, however, market prices are a poor reflection of those costs, and the financial assessment of the project usually differs markedly from the economic assessment. A major aim of economic analysis is to assess the project's contribution to the society's welfare. This evaluation requires that the analyst compensate for price distortions by using "shadow" prices that reflect more closely the opportunity costs and benefits of the project, instead of market prices. Although in principle all prices should be adjusted to reflect opportunity costs, these calculations would be extremely time-consuming and expensive. In practice, only a few adjustments are undertaken. The most important adjustments concern the prices of tradeable goods, the exchange rate, and the wage rate.

Tradeable and Nontradeable Goods

3. Typically, a project's inputs include material inputs, public utilities, labor, land, and services. Some of these goods and services are tradeable, some are nontradeable, and others are not traded but are potentially tradeable. These distinctions are important because the valuation of each type of good is different. Traded goods include those that are either imported or exported by the country. Tradeable goods include all traded goods and goods that the country could import (or export) under conditions of free trade, but it does not trade because of such trade barriers as import duties; material inputs are normally tradeable goods. Nontradeable goods are those that by their nature either cannot be traded or are uneconomical to trade internationally. Real estate, hotel accommodations, haircuts, and other services are typically nontradeable. Nontradeable goods also include goods whose costs of production and transportation are so high as to preclude trade, even under conditions of free trade. In principle, a good falls into this category if its CIF cost (landed price) is greater than the local cost, precluding importation, *and*, at the same time, its local cost is greater than the FOB price, precluding exportation. Most of the material inputs that go into Bank projects are tradeables. In some cases electric energy and transportation might be nontradeable. Land is always a nontradeable good.

4. To determine whether a good is tradeable or nontradeable, the first step is to ascertain whether the good is internationally traded. If no international trade exists, then it is safe to assume that the good is nontradeable. If international trade takes place, but not in the country where the project is to take place, the second step is to estimate the relevant CIF and FOB prices and to compare them to the domestic price. If the CIF price (net of import duties and subsidies) of the good is higher than its domestic price, then the good is clearly not importable. If its FOB price (net of export duties and subsidies) is lower than the domestic price, then the good is clearly not exportable.[1] If, on the other hand, imports are not coming into the country because, for example, import duties render the import price higher than the domestic price, international trade is not taking place because of distortions, but the good is potentially a traded good. Likewise, if export duties make exports uncompetitive, the good is potentially a traded good. All such potentially traded, but nontraded, goods should be treated as nontradeable goods.

Valuation of Tradeable Goods

5. For various reasons, domestic market prices typically do not reflect the opportunity costs to the country. In many countries, for example, import duties increase the price of domestic goods above the level that would prevail under conditions of free trade. If the domestic price of inputs is far higher than under conditions of free trade, a project that uses the protected input may have a low financial expected NPV. Likewise, if a project produces a good that enjoys protection, the financial NPV of the project may be higher than under conditions of free trade. To approximate the opportunity costs to the country, the valuation of tradeable inputs and outputs in economic analysis relies on "border" rather than on domestic market prices.[2]

6. Border prices are either CIF or FOB prices suitably adjusted for internal transport costs and other costs, but net of taxes and subsidies. If the country is a net exporter of the good in question, the appropriate border price is the FOB price of exports (also known as export-parity price). If the country is a net importer, the appropriate border price is the CIF price of imports plus internal transport costs (or import-parity price).

7. Table 5.1 and 5.2 show sample calculations of border prices taken from Gittinger (1982a, pp. 80-82). In table 5.1, Gittinger is trying to determine the price at which an import substitute (maize, in this case) must be produced domestically if it is to compete with imports. Gittinger begins with the price of No. 2 U.S. yellow corn in bulk at a U.S. port: $116 per ton. He then adds freight, insurance, and transport to Lagos (or Apapa), Nigeria, and arrives at a landed cost of $147, or N91 at the then-prevailing exchange rate of $1.62 per naira. Gittinger then estimates landing and port charges plus internal transport to a wholesale market at N40, for a total of N131. Presumably, farmers would be able to sell their maize at N131 in this market, but to do so they would have to incur transport costs and some storage losses, which Gittinger estimated at N41 per ton. If we subtract these costs, the farmgate price becomes N90 per ton: the import-parity price at the farmgate.

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[1] Of course, the exchange rate is crucial in this calculation. A nontradeable may become an export if the real exchange rate falls.

[2] The Technical Annex provides a theoretical justification for using border prices as the prices that reflect the opportunity costs to the country.

Table 5.1. Import-Parity Price of Early-Crop Maize, Nigeria
(1976 prices)

Step in the calculation	*Relevant step in the Nigerian example*	*Financial Price per ton*
FOB at point of export	FOB U.S. Gulf Ports (No. 2 U.S. yellow corn in bulk)	US$116
Add freight, insurance, and unloading at point of import	Freight, insurance, and unloading at point of import CIF Lagos or Apapa	US$31
Equals CIF at point of import		US$147
Convert foreign currency to domestic currency at official exchange rate	Converted at official exchange rate of N1 = US$1.62	N91
Add local port charges	Landing and port charges (including cost of bags)	22
Add local transport and marketing costs to relevant market	Transport	18
Equals price at market	Wholesale price	N131
Deduct transport and marketing costs to relevant market	Primary marketing (includes assembly, cost of bags, and intermediary margins)	14
Deduct local storage, transport, and marketing costs (if not part of project cost)	Transport Storage loss (10 percent of harvested weight)	18 9
Equals import-parity price at farmgate	Import-parity price at farmgate	N90

Source: Gittinger, 1982a, p. 82

8. Table 5.2 shows similar calculations for an export-parity price. The question here is, what price would farmers receive if they must produce for export? Gittinger begins with the price of cotton in Liverpool, England: $639 per ton for cotton lint and $103 for cotton seed. Gittinger estimates both prices because a cotton farmer receives revenues from the sale of both lint and seed. To get the lint and the seed from Port Sudan to Liverpool, an exporter would have to pay $40 and $28 per ton, respectively, in freight and insurance, netting $599 for lint and $79 for seed. In domestic currency, these prices would be the equivalent of £Sd208 and £Sd27, respectively. From the domestic price equivalents, we deduct export duties, port handling charges, and local transport from the market to Port Sudan, for net prices of £Sd179 for lint and £Sd18 for seed. To calculate the farmgate price, it is necessary to convert these prices to their seed cotton equivalent—the product that farmers sell. Gittinger weights the prices of the two products by their respective yields from a ton of seed cotton to obtain the export-parity price of seed cotton.[3] He then deducts the costs of ginning, bailing,

[3] Gittinger actually used three products. To simplify the presentation, we have omitted the third, scarto, a by-product of very short, soiled fibers.

Table 5.2. Financial Export-Parity Price for Cotton, Sudan
(1980 prices)

Step in the calculation	*Relevant step in the Sudanese example*	*Price per ton* *Lint*	*Seed*
CIF at point of import	CIF Liverpool (taken as estimate for all European ports)	US$639.33	US$103.39
Deduct unloading at point of import, freight to point of import, and insurance	Freight, insurance, and handling	39.63	24.73
Equals FOB at point of export	FOB Port Sudan	US$599.70	US$78.66
Convert foreign currency to domestic currency at official exchange rate	Converted at official exchange rate of £Sdl.00 = US$2.872	£Sd208.81	£Sd27.39
Deduct export duties	Export duties	17.81	1.00
Deduct local port charges	Port handling	5.56	1.51
Deduct local transport and marketing costs from project to point of export (if not part of project cost)	Freight to Port Sudan at £Sd6.78 per ton	6.78	6.78
Equals export-parity price at project boundary	Export-parity price at gin at project site	£Sd178.66	£Sd18.10
Conversion allowance, if necessary [a]	Convert to seed cotton (£Sd178.66 x 0.40 + £Sd18.10 x 0.59)	71.46	10.68
Equals price of seed cotton			£Sd82.14
Deduct local storage, transport, and marketing costs (if not part of project cost)	Ginning, baling, and storage (£Sd15.229 per ton)		-15.23
	Collection and internal transfer (£Sd1.064 per ton).		-1.06
Equals export-parity price at farmgate	Export-parity price at farmgate		£Sd65.85

Source: Gittinger, 1982a, p. 82
[a] Conversion assumption: 1 ton of seed cotton yields 400 kilograms of lint and 590 kilograms of seed.

transportation, and storage and arrives at the export-parity farmgate price of £Sd65.85. Note that the relevant prices in these examples are those that the farmer would receive (or pay) at the point where the project is located. This general principle should always be followed in economic analysis: the relevant prices are measured at some common point, usually the location of the project—for example, at the farmgate or ex-factory.

Shadow Exchange Rate

9. In tables 5.1 and 5.2, prices expressed in foreign exchange were converted to domestic currencies using the official exchange rate. However, the official, or even the market, exchange rates may not reflect the economic value in units of domestic currency of a unit of foreign exchange. Trade policies (e.g., import duties, quantitative restrictions, export subsidies, export taxes) distort not only individual prices of goods, but also the price of foreign exchange for the economy as a whole. Whenever serious trade distortions are present, border prices need to be converted into domestic currency equivalents using a shadow exchange rate, not the official or market exchange rate. A shadow exchange rate is appropriate even if there are no balance-of-payments problems, or if the official exchange rate is allowed to adjust freely. The relevant question is whether there are trade distortions. In general, the shadow exchange rate equals the market (or official) exchange rate only if all trade distortions, such as import duties and export subsidies, are eliminated. Because most countries impose import duties and some grant export subsidies, it is generally good practice to adjust the market exchange or official exchange rate for these distortions. The Technical Appendix provides guidelines for calculating shadow exchange rates. To illustrate the *use* of the shadow exchange rate, we will assume that the shadow exchange rate in Sudan was 10 percent higher than the market rate.

10. Under this assumption, the value of any export to the economy was 10 percent higher than to the individual exporter. This excess value, or premium, affects the economic costs or benefits of a project. In the case of Sudan, it would have meant that the value to the country of every dollar of exports would have been £Sd0.383 instead of only £Sd0.348. Instead of converting the price of tradeables in U.S. dollars at the official exchange rate, we would have used £Sd0.383. The value of lint in domestic currency would then have been £Sd230 instead of £Sd209. In short, instead of converting values into domestic currency using the official rate, we would simply have used the shadow rate.

Premium on Foreign Exchange

11. A difference between an economic and a financial price is an indication of a rent (or tax or subsidy) accruing to (or being paid by) someone other than the project entity. The difference between the economic and official or market price of foreign exchange is an example of such a case. To identify the group that appropriates the difference, it is necessary to identify the source of that difference.

12. Take a country with a uniform import duty of 15 percent and no taxes or subsidies on exports. Let us say that in this country the exchange rate is market determined and that it is 5:1 with respect to the U.S. dollar. For every dollar of imports, every importer surrenders 5.75 units of domestic currency (5 units to purchase dollars plus 15 percent to pay for import duties). Exporters, on the other hand, receive 5 units of domestic currency for every dollar of exports. The import duty introduces a distortion that drives a wedge between what importers must pay in order to import one dollar's worth of goods and what exporters receive when they export one dollar's worth of goods. Because of this difference, the economic price of foreign exchange is not equal to the market rate.[4]

13. As the Technical Appendix explains, in this country the economic cost of foreign exchange would be a weighted average of 5 and 5.75. The weights will depend on the relative shares of imports and exports in the country's external trade and on the elasticities of demand for exports and supply of imports. If the

[4] It is important to note that a difference between the financial and economic cost of foreign exchange could exist even in a country with a market-determined exchange rate.

demand for imports is very elastic and the supply of exports is very inelastic, the economic cost of foreign exchange will be closer to 5.75 than to 5. Let us assume that the weights are 0.8 for imports and 0.2 for exports and that the economic cost of foreign exchange is therefore 5.60. Such a value would imply that that there is a premium on foreign exchange of 12 percent (5.6/5 = 1.12) over the market rate. A project that uses foreign exchange will cost the economy 5.6 units of domestic currency for every dollar of exports, yet importers will only pay 5.0 (net of import duty). What happens to the difference?

14. In this case, the difference is a government loss. To the extent that the government diverts foreign exchange from general use to the use of the project, the diversion has a fiscal impact. This fiscal impact can be seen if we consider what happens when the government enters the market for foreign exchange to use in a project. The additional government demand raises the price of foreign exchange ever so slightly. As a result of the higher price, existing consumers will import less and there will be some increase in exports. Because, in this example, exports do not receive subsidies nor pay taxes, the expansion in exports has no fiscal impact, but the reduction in imports does. For every dollar that imports are reduced, the government loses 15 cents in import duties. But not every unit of foreign exchange diverted to the project is met from a reduction in imports. In this example, every unit of foreign exchange diverted to the project is met by an 80-cent reduction in imports and hence a 12-cent reduction in import duties, and a 20-cent increase in exports. The 12-cent reduction in revenue is exactly equivalent to the premium on foreign exchange.[5] Of course, since all imports pay 15 percent duty, for every unit of foreign exchange imported by the project, the government will recover 15 cents. The net fiscal impact would be a positive 3 cents in foreign currency (or 15 cents in domestic currency). The difference between the financial and economic price (measured in domestic currency) of every dollar of imports would be as follows:

		Fiscal impact:	
Economic price +	Import duty –	Premium on foreign exchange =	Financial price
5.60	+0.75	-0.60	5.75

15. In general, if the premium on foreign exchange is α percent of the value of foreign exchange and the duty on an input is β percent of its price, the fiscal impact of diverting one unit of foreign exchange to a project for the importation of that input will be (β - α) percent. The fiscal impact will be exactly symmetrical for exports. If the premium on foreign exchange is α percent and the project produces an export that receives a subsidy of γ percent, the fiscal impact of every unit of foreign exchange earned by the project will be equal to (α - γ) percent.

16. If for the sake of simplicity we ignore internal transport costs and other transactional costs, the relationships among financial prices, border prices, economic prices, and fiscal impact for imports can be expressed as follows:

financial price - duty = border price
border price + premium on foreign exchange = economic price
fiscal impact = duty - premium on foreign exchange.

Similarly, the relationships among financial prices, border prices, and economic prices and fiscal impact for exports can be expressed as follows:

financial price - subsidy = border price

[5] The proportions by which import compression and export expansion meet the additional demand are a direct logical consequence of the assumptions. 5.6 is a weighted average of 5.75 and 5.0: 5.75a + 5.0(1-a) = 5.6. This equation implies that a = 0.8. For further details on the calculation of the weights, see the Technical Appendix.

border price + premium on foreign exchange = economic price
fiscal impact = premium on foreign exchange - subsidy

17. These relationships hold as long as the premium on foreign exchange stems solely from taxes and subsidies on international trade. In some countries, international trade (including the market for foreign exchange) is subject to quotas, and some groups in society, other than the government, may enjoy rents stemming from the distortions. In these cases, the premium on foreign exchange would not accrue solely to the government, but would also accrue to the groups enjoying these rents. To assess who enjoys the premium, it is essential to identify the source of the distortion.

Other Sources of Premia

18. Market imperfections also generate rents. For example, Andreou et al. (1991) estimated that in Cyprus the financial price of automobiles was some 48 percent above the economic price. Of this total they estimated that policy-induced distortions accounted for 39 percent and market imperfections for 9 percent. The sources of divergence between economic and financial prices were as follows:

	Project entity	*Government*	*Distributors*	*Total*
CIF price	(2,370)			(2,370)
Duties	(1,660)	1,660		0
Premium on foreign exchange		(332)		(332)
Distribution margin	(680)			(680)
Monopoly rents	(290)		290	0
Total	(5,000)	1,328	290	(3,382)

19. The financial price of an imported automobile would be 5,000 Cyprus pounds (shown in parentheses to indicate costs to the relevant stakeholder), whereas the economic price would be about 3,382. Of the difference between the two prices, 1,328 would be accounted for by the net fiscal impact on the government (which would collect 1,660 pounds in import duties, but lose 332 pounds from the premium on foreign exchange). Another 290 pounds would be accounted for by the rents accruing to automobile distributors by virtue of the their monopoly position. Similar breakdowns can be done in every instance where the financial and economic prices differ and in every instance where financial and economic flows differ.

Valuation of Nontradeable Goods and Services

Material Inputs

20. Domestic distortions may alter prices of nontradeable goods. In principle, adjustments may be necessary if the prices that enter into economic analysis are to reflect opportunity costs. However, the calculation of shadow prices for nontradeable goods can be extremely time-consuming, and the project analyst must decide whether the refinement is worth the additional effort. If the share of nontradeable material inputs in total project costs is small and the NPV of the project is not sensitive to variations in their price, then shadow pricing nontradeable material inputs may not be worth the cost of gathering the necessary information. The Technical Appendix provides guidelines for the estimation of shadow prices of nontradeable material inputs.

Land

21. Land is a prime example of a nontradeable good. In this respect its valuation is, in principle, no different from that of any other nontradeable good. Land differs from other tradeable goods, however, in that its supply is totally inelastic: any land diverted to the project is necessarily taken away from some

other use (even if that use is speculation). Therefore, the valuation of land for project use may have to rely on indirect methods, rather than on straightforward use of market prices adjusted for distortions.

22. If an active land market exists, land purchased specifically for project use may be costed as a *capital value* using the price paid (adjusted for distortions), if the analyst thinks that the market is sufficiently representative of alternative use values for the land.[6] If the land is rented, then the rental value (adjusted for distortions) should be considered in the project analysis.

23. Often, however, the market for land is imperfect, and the market price is difficult or impossible to estimate. Many Bank projects involve land that has been in the possession of project participants for a number of years. For example, forestry projects may be proposed for land that a government agency has owned for decades, or a factory expansion may be proposed for land that was acquired at start-up in anticipation of future expansion. In these cases, to measure the value of the land in its alternative use, it is necessary to impute a price. This computation can be done by estimating the NPV of its rental price. The following relationship is useful in this regard:

$$V = R/(i - g)$$

where V stands for the imputed value of a parcel of land, R for the annual "rent" or income from the land, i for the interest rate or opportunity cost of capital, and g for the expected real growth rate of GDP. Note that this equation may lead to an *undervaluation* of land because it assumes that the demand for land is purely a function of its rental value. However, landowners may want land for many other reasons—as an inflation hedge, or for prestige, or to acquire voting rights, for example. The price of land estimated through this equation does not necessarily reflect the demand arising from such other uses and may be underestimated as a result. Nevertheless, this equation is an important input in many of the shortcuts that are used in economic analysis to relate annualized opportunity costs with capitalized values for land, and implies a residual value for land equal to $V(1 + g)^t$.

Wages

24. In countries where the labor market functions smoothly, the wage actually paid is adequate for both financial and economic analysis. However, government interventions in the labor market (e.g., minimum wage legislation, legal impediments to labor mobility) introduce distortions that make it necessary to use shadow wage rates to reflect the opportunity cost of using labor in a project.

25. The shadow wage rate is *not necessarily* equal to the marginal output of labor. If, in an economy with widespread unemployment, the project uses redundant labor, such a definition would lead to the conclusion that the shadow wage rate would be zero. Such a definition, however, ignores the fact that no one wants to work for free: there is some "reservation wage" below which people prefer being unemployed to taking a job. The reservation wage depends on people's income situation while unemployed, the value of leisure and other nonwage activities (such as fishing or fixing the roof), and the nature of the project employment. Thus, even if there were widespread unemployment and no production would be forgone in the rest of the economy if the project were to employ one more worker, the shadow wage rate would still be greater than zero. There are other reasons why the shadow wage rate may not be zero: in some cases the creation of one additional job in the urban sector may induce several workers in the rural sector to migrate. In those cases the forgone output becomes a multiple of one worker's marginal product. It is always appropriate, therefore, to use a set of shadow wage rates for different skills, times, and locations, rather than a single rate for the whole country. The Technical Appendix provides guidelines for calculating these

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[6] If a capital value is used in costing the land in the project accounts, then a *residual value* should be included at the end of the project life. Broadly speaking, the residual value of land will remain constant relative to GDP, as implied by the equation in para. 14. If the annual rental/lease charge is used in costing the land, then no residual value should be shown for the land at the end of the project life.

rates. There are two important points to bear in mind, though: first, the market wage rate often needs to be adjusted to reflect the opportunity cost of labor, and second, the opportunity cost of labor is greater than zero unless people are willing to work for free.

26. Before embarking on detailed calculations of the shadow wage rate, however, it is advisable to test the project's sensitivity to the wage rate. The analyst can use as an upper bound the wage paid in the urban areas for the appropriate skill level and as a lower bound the wage paid for the same skill level in the rural areas. If the project's NPV does not vary substantially in response to changes in the wage rate used, then using the market wage rate would be an acceptable shortcut.

Conversion Factors

27. Many analysts use *conversion factors* to conduct economic appraisals of projects. A conversion factor is the ratio of an item's economic price to its financial price. Whether the analyst uses conversion factors or economic prices does not alter the conclusions of the analysis. In many cases, however, conversion factors are more convenient than economic prices. First, conversion factors can be applied directly to the financial data. Second, as long as the underlying tax and subsidy distortions remain unchanged in percentage terms relative to the price of the good, conversion factors are unaffected by inflation. Finally, *as long as the underlying distortions remained unchanged*, conversion factors calculated for one project can be applied to other projects in the same country.

28. The calculation of conversion factors is straightforward if we know the economic and financial prices. Take for example the price of cotton calculated in table 5.2. The net effect of the export tax (£Sd17.81 per ton of lint and £Sd1.00 per ton of seed) that Sudan imposed was to lower the financial export-parity farmgate price of seed cotton to £Sd65.85, compared to an economic price of £Sd83.53 obtained by converting the dollar FOB price to domestic currency at the shadow exchange rate and adjusting for duties. The ratio of these two prices is 1.27:1. We would underestimate by 27 percent the benefits of any project that produced cotton if we used the financial instead of the economic price. Similarly, we would overestimate the benefits of any project using cotton as input.

29. Although conversion factors have many advantages, they need to be complemented with additional information if we want to extend the analysis and identify gainers and losers. In particular, we need to identify the reasons that explain the divergence between economic and financial prices. In the Sudan example, the difference between the economic and the financial prices represents transfers between members of the society. Farmers get only £Sd65.85 per ton of cotton. The benefits to society, however, amount to £Sd83.53. Who gets the difference? In this case the government gets the difference because the distortions stem solely from taxes. Export taxes account for £Sd7.71 and the foreign exchange premium for £Sd9.97; therefore, the government increases its tax revenues by £Sd7.71 and captures the foreign exchange premium of £Sd9.97 for every ton of cotton that is exported:

	Farmers	*Government*	*Totals*
Farmgate price	65.85		65.85
Export taxes		7.71	7.71
Foreign exchange premium		9.97	9.97
Totals	65.85	17.68	83.53

This breakdown is lost when we use *only* conversion factors. As chapter 12 will discuss, to identify gainers and losers, it is necessary to decompose conversion factors and determine the sources of difference between financial prices and economic prices. If the conversion factor is less than or greater than 1, this immediately signals a distortion that entails a transfer to or from the project entity to some group in society. A complete assessment of the project integrating the financial, fiscal, and economic analyses, requires that the group or groups that receive or generate the transfers be identified.

Marginal Cost of Public Funds

30. Whenever a government taxes, it creates a distortion and imposes a cost to the economy.[7] From society's point of view, this cost causes the marginal cost of funds raised by taxes to exceed the amount of funds actually raised and used and thus creates an additional cost incurred by any project that is a net user of public funds. If $(1 + \Sigma)$ denotes the marginal cost of public funds, and PV(NFI) the present value of the net fiscal impact of the project, then the cost of the fiscal impact will be given by $PV(NFI)x(1 + \Sigma)$. Notice that the adjustment factor $(1 +\Sigma)$ will lower the NPV of project that is a net user of fiscal funds and raise the NPV of a project that has a positive fiscal impact.

31. The value of the adjustment factor Σ is seldom available. For this reason, a practical approach is to calculate the project's fiscal impact and test for the project's NPV sensitivity to the value of Σ. However, if both the project's fiscal impact and NPV are positive, then there is no need to carry out a sensitivity analysis at all. What are plausible values of Σ? Empirical estimates of Σ range from 0.17 to 1.29 (Devarajan et al., 1996). Nevertheless, some authors think that any value greater than 0.4 is suspect (see, for example, Harberger, 1995). Within the Bank, analysts should look to the Development Economics vice-presidency for guidance on the value of Σ.

[7] Unless the tax is a lump-sum tax.

Chapter 6. Valuing Environmental Externalities

Externalities

1. Sometimes a project uses resources without paying for them. For example, a factory may emit soot that dirties surrounding buildings, increasing their maintenance costs. The higher maintenance costs are a direct result of the factory's use of a resource, air, that from its point of view is free but that has a cost to society. Likewise, a new irrigation project may lead to reduced fish catch or the spread of a disease. Sometimes a project makes certain groups better off, but the nature of the benefits is such that the project entity cannot extract a monetary payment for them. For example, if a forest lowers the level of carbon dioxide in the world, the forest owners cannot charge for the benefit. Or, for example, a sewage and water supply project may not only improve water quality and yield direct health benefits but may also produce benefits from decreased pollution of coastal areas, in turn increasing recreational use and property values. These effects, known as "externalities," are real costs and benefits attributable to the project and should be included in the economic analysis as project costs or as project benefits.

2. Conceptually, the externalities problem is quite simple and can be described as a difference between the benefits (costs) that accrue to society and the benefits (costs) that accrue to the project entity. Externalities occur in production and consumption and in just about every walk of life. Involuntarily inhaling another person's smoke is an example of an externality. The smoker's pleasure produces displeasure in another person. To assess the total pleasure derived from smoking, it would be necessary to reduce the smoker's pleasure by the displeasure of the person who involuntarily inhales the smoke. The main problem with externalities is measuring them: although it easy to understand how smoking may produce an externality, it is not easy to assign a value to the smoker's pleasure or to the inhaler's displeasure.

3. The externalities problem is even easy to depict. Consider the production of some good, say electricity. Suppose that in producing electricity, the plant emits soot that increases the maintenance costs of adjacent buildings. The utility company's costs would not reflect the costs to the neighbors of cleaning up the adjacent buildings (unless the law requires it). Yet the costs to society of generating electricity include not only those that appear on the books of the utility company, but also the additional maintenance costs of the adjacent buildings. In figure 6.1, MPC is the marginal cost of producing electricity as reflected in the books of the utility company, and MSC is the marginal cost of producing electricity *and* cleaning up the buildings. MSC is the marginal *social* cost of producing electricity. Evidently, this cost would be higher than the private cost (the cost to the utility company). For any given level of output, say q*, the total cost of producing that level of output is given by the area under the curve. The difference between the areas under the two curves gives the difference between the private and the social cost. The financial costs of the project will not include the costs of the externality, and hence an evaluation of the project based on MPC will understate the social costs of the project and overstate its net benefits. In principle, all we need to do to account for the externality is to work with social rather than private costs. In practice, the measurement difficulties are tremendous because often the shape of the MSC curve, and hence its relationship to the MPC curve, is unknown. Also, it is not always feasible to trace and measure all external effects. Nevertheless, an attempt should always be made to identify them and, if they appear significant, to measure them. When externalities cannot be quantified, they should be discussed in qualitative terms.

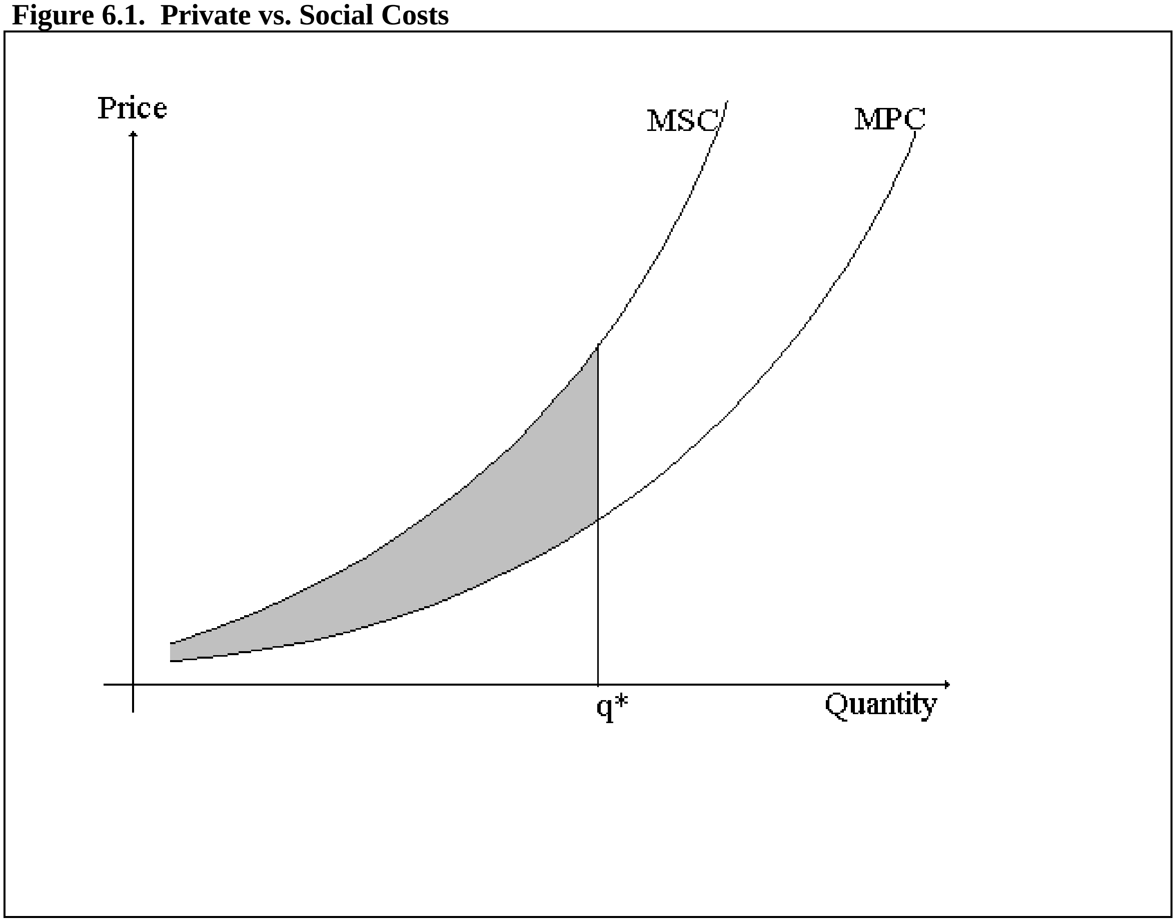
4. In some cases it is helpful to "internalize" externalities by considering a package of closely related activities as one project—that is, to draw the "project boundary" to include them. For example, in the case of the soot-emitting factory, the externality could be "internalized" by treating the factory and the neighboring buildings as if they belonged to the project entity. In such a case, the additional maintenance costs become part of the maintenance costs of the project entity and are "internalized." If the factory pays for the additional maintenance costs, or if the factory is forced to install a stack that does not emit soot, the externality also becomes internalized. In these cases, the formerly "external" cost becomes an "internal" cost that is reflected in the accounts of the factory.

Environmental Externalities

5. Environmental externalities are a particular form of externalities that good economic analysis should take into account. Environmental externalities are identified as part of the environmental assessment, quantified where possible, and included in the economic analysis as project costs (as might be the case for decreased fish catch, or increased illness) or benefits (as might be the case with the reduction in pollution of coastal areas). After a monetary value is assigned to the costs and benefits, they are entered into the cash flow tables as any other costs and benefits are.

Project Boundaries and Time Horizon

Figure 6.1. Private vs. Social Costs



6. Analysts must make two major decisions when assessing environmental impacts. First, they must decide how far to look for environmental impacts—that is, they must determine the

boundary of the economic analysis. Whenever we assess the internal benefits and costs of a project, the boundaries of the analysis are clear: if the benefits accrue to the project entity or if the costs are borne by the project entity, they enter into the analysis. When we attempt to assess the externalities of a project to determine its impact on society, the boundaries become blurred. Identifying externalities implies expanding the conceptual and physical boundaries of the analysis. A mill that generates wastewater that will adversely affect downstream uses of water—drinking, irrigation, fishing. Other impacts on the environment may be more distant or more difficult to identify: the effects of emissions from a power plant on creation of acid rain, for example. How far to expand is a matter of judgment, and depends on each individual project.

7. The second decision concerns the time horizon. Like the project's physical boundaries, its time horizon also becomes blurred when we go from financial to economic analysis. A project's environmental impact may not last as long as the project, or it may outlive it. If the environmental impact lasts less time than the expected economic life of the project, the effects can be included in the standard economic analysis. If, on the other hand, the effects are expected to last beyond the lifetime of the project, the time horizon must be extended. This can be done in two ways, either by extending the cash flow analysis a number of years, or by adding to the last year of the project the capitalized value of that part of the environmental impact that extends beyond the project's life. The latter technique treats the environmental impact much as one would treat a project's capital good whose life extends beyond the project's lifetime by giving it a "salvage value."

Valuation of Environmental Impacts

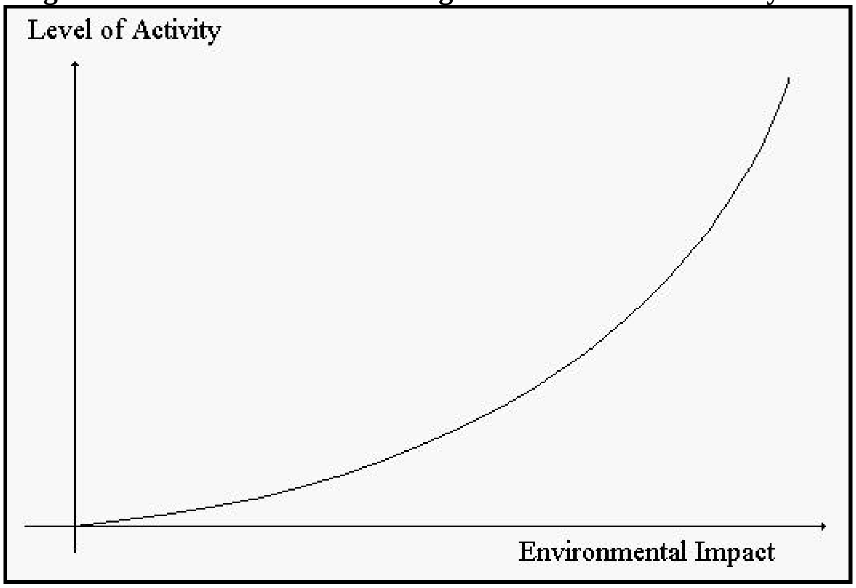
8. The first step in assessing costs or benefits of environmental impacts is to determine the functional relationship between the project and the environmental impact, that is, to determine a relationship such as the one depicted in figure 6.2. The second step is to assign a monetary value to the environmental impact. These two steps are equivalent to determining the shape of the MSC curve and its relationship to the MPC curve in figure 6.1. For example, suppose that we have a project whose objective is to reduce air pollution. The first step is to determine the impact of the project on the quality of air, as measured by some physical characteristic. The second step is to assess the monetary value of the improvement in air quality. In most cases, we do not need to estimate the entire cost curve; it suffices to identify the cost (or benefit) of an externality at a given level of activity, that is, it is enough to estimate the difference between the private and the social cost for a given level of activity.

9. Conceptually, four cases can be distinguished:

	Market value exists	*Market value does not exist*
Functional form is known	Case 1	Case 3
Functional form is unknown	Case 2	Case 4

The more difficult cases are those in which the market value of the externality is not readily available, i.e., cases 3 and 4, of which the most difficult is case 4, where neither the market value nor the functional relationship between the level of the activity and the environmental impact is known. A number of functional relationships that relate the level of activities to the degree of physical damage (or benefit) have been developed for various environmental impacts. Environmental damages include changes in production (e.g., of crops or fisheries affected by polluted water), changes in health, or damage to infrastructure due to air or water pollution, and even loss of aesthetic benefits or recreational opportunities. We now turn to the various methods available for valuing environmental externalities.

Figure 6.2. Environmental Damage as a Function of Activity Level



10. *Objective valuation techniques* are based on technical and/or physical relationships that can be measured. They rely on observable environmental changes and on market prices of goods or services (or expenditures). *Subjective valuation techniques* are based on behavioral or revealed relationships. Frequently, they use surrogate measures to estimate values; that is, the analyst uses a value for a marketed good to infer a value for an unpriced environmental good or service. The subjective measures rely on surrogate markets, hypothetical markets (based on surveys), or implicit values as expressed by various "hedonic" techniques. Subjective techniques offer the only practical way to measure certain categories of environment-related benefits and costs, and they are increasingly accepted for decision making.

11. The choice of valuation technique depends on the impact to be valued; data, time, and financial resources available for the analysis, and the sociocultural setting within which the valuation exercise is carried out. Some valuation approaches are more robust, and more likely to applied, than others.

12. It is important to remember that frequently *the simplest techniques are usually the most useful*. In most Bank projects the most useful valuation techniques are those that rely on actual changes in production, on replacement costs or preventive expenditures, or on information about impacts on human health (cost of illness). All of these deal with physical changes that can be valued using market prices and are all included in the objective set of techniques.[1]

Loss in Productivity

13. A project may raise or lower the productivity of another system. In these cases the valuation is fairly straightforward. For example, in Fiji, conversion of a coastal wetland to an industrial site resulted in lower catches in a coastal fishery that was partly dependent on the wetland. The monetary value of the reduction in catch was an economic externality attributable to the industrial development project and hence an economic cost of the project. The loss in

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[1] For more detailed information on these and the other techniques, see Dixon, Scura, Carpenter, and Sherman (1994).

production had an assessable market value. Because the lower production was accompanied by lower costs of production, the change in net benefits yielded the net impact of the externality. Box 6.1 illustrates the use of the change-in-production approach in a project in the Philippines.

Box 6.1. Assessing Disposal Alternatives for Geothermal Wastewater in the Philippines

The change-in-production approach was used to assess the impacts of various means of disposing of toxic geothermal wastewater from a geothermal power development project on the island of Leyte, the Philippines. The analysis considered seven different disposal options—including reinjection of geothermal wastewater, untreated disposal in local rivers, and use of ocean outfalls—estimating the economic costs of their impacts on irrigated rice production and on an offshore fishery.

Polluted surface water could no longer be used for irrigation of 4,000 ha in the dry season (rain-fed crop production would continue during the wet season, but with lower average yields). The net return per ha was estimated at P346 for irrigated rice, and P324 for rain-fed rice. The economic cost of the loss of decreased agricultural production for 4,000 ha was therefore the difference between the net return from two irrigated crops (4,000 ha x 2 crops x P346/ha = P 2,768,000) and the net return from one crop of unirrigated rice (4,000 ha x 1 crop x P324 = P 1,296,000). This difference represented an annual loss of some P1.47 million.

In a similar fashion the change-in-production approach was applied to a coastal fishery. Disposal options that did not include treatment of wastewater would cause heavy metal pollution of coastal waters that would close the coastal fishery. The cost of this loss was calculated by multiplying the value of the annual catch (P39.4 million) by the net return to fishing (estimated at 29 percent), for an annual loss valued at P11.4 million.

Both of these annual costs were then capitalized to represent the economic damage to rice and fishery production from environmental pollution. Other environmental costs were also calculated (some in a qualitative manner). All this information was used to help assess the total benefits and costs of the various wastewater disposal management alternatives.

Source: Balagot and Grandstaff (1994).

14. A project could, of course, have an environmental benefit. The Loess Plateau Soil Conservation Project in China, for example, was designed primarily to control erosion and increase agricultural productivity. In addition, however, the project helped reduce sedimentation and thus saved the costs of dredging the sediment (see box 6.2).

15. In some cases, the impact of the project is not on the *levels* of production, but on the *costs* of production or consumption. For example, buildings may require more frequent painting as a result of a nearby factory that emits pollutants. The higher maintenance costs should be included as a cost of the factory in economic analysis.

Dose-Response

16. Some investment projects yield important health benefits from reduced mortality and morbidity (e.g., infant and child health programs, increased potable water supply, improved sewage collection and treatment, and programs to reduce vehicular pollution). Other investments may have unintended, but important, negative impacts on health: expanded industrial production or new thermal power plants produce important economic benefits while also resulting in some undesirable environmental externalities. These health impacts should be identified and incorporated in the economic analysis in either a qualitative or quantitative manner.

Box 6.2. Estimating Downstream Costs of Soil Erosion in China

The project under consideration was a watershed protection/erosion control project in the middle reaches of the Yellow River, designed primarily to increase agricultural productivity in the Loess Plateau. It was calculated that the project would reduce sedimentation by about 41 million tons annually, or about 1.2 billion tons over the entire 30-year life of the project. This amount represented an annual reduction of about 2.6% in the sediment load of the Yellow River.

An average of approximately 150 million tons of sediment reached the irrigation systems in the lower reaches of the Yellow River each year. Of this amount, approximately 30 million tons were removed by dredging and other means. Sediment reduction in the Loess Plateau would mean reduced dredging costs. The value of reduced irrigation dredging costs was estimated at RMB yuan 0.07 per ton of sediment retained in the Loess Plateau. This per-ton value was then multiplied by the estimates of reduced erosion in the Loess Plateau (yuan 0.07/ton x 41 million tons/yr). The benefits resulted in an increase in the NPV. The project's internal rate of return increased from about 19% to about 22%.

Source: Magrath (1994).

17. For air pollution a *dose-response relationship* (DRR) is commonly used to link changes in ambient pollution levels to health outcomes. The DRR is a statistically estimated relationship between the levels of certain pollution in the air and the different health outcomes—the level of illness, lost workdays, and so forth. Although DRRs were developed in the United States and Europe, the approach is increasingly being transferred to other countries. Recent Bank work in Jakarta (Ostro 1994) and Chile (Eskeland, 1994) illustrates what can be done (see box 6.3).

18. Water pollution is different from air pollution: whereas everyone breathes the same air in any location, a person must actually come in contact with or ingest polluted water to become ill. Since individuals can "self-insure" themselves from the effects of contaminated water by boiling their water or using bottled water, epidemiological studies are usually required to estimate the impacts of changes in water quality on different health outcomes. These studies take into account the important social and economic factors that determine the links between contaminated water and illness and death.

19. Once a project's impacts on health have been identified, they can be quantified in physical terms, and, where feasible, valued in monetary terms. It is possible to use indirect means to assign a monetary value to some health benefits. For illness, for example, it is possible to estimate the costs due to medical treatment and hospitalization (doctor's visits, medicine, hospital costs, lost work time). It is more difficult to estimate the "cost" of pain and suffering to the sick individual, relatives, and others. Thus, the measured costs of illness based on direct expenditures (or their appropriate shadow prices) are a *minimum estimate of the true costs of illness,* and, in turn, the potential benefits from preventing morbidity.

Box 6.3. Using Dose-Response Relationships to Estimate Health Outcomes in Jakarta

This case study illustrates the use of *dose-response relationships* (DRRs) to estimate the health impacts of air pollution reduction. The health impact can be estimated by the following relationship:

$$dH_i = b_i * POP_i * dA$$

where dH_i stands for the change in population risk of health effect i; b_i for the slope from the dose-response curve for health impact i; POP_i for the population at risk of health effect i; and dA for the change in ambient air pollutant under consideration.

In Jakarta, foreign dose-response functions were applied to local conditions to assess the annual benefits of reducing airborne pollution to meet both Indonesian and the more stringent WHO standards. The estimated numbers of lives saved and illnesses avoided in the population of 8.2 million follow:

Health effect	*Problems avoided: medium estimate*
Premature mortality	1,200
Hospital admissions	2,000
Emergency room visits	40,600
Restricted activity days	6,330,000
Lower respiratory illness	104,000
Asthma attacks	464,000
Respiratory symptoms	31,000,000
Chronic bronchitis	9,600

Source: Ostro (1994).

20. For death, on the other hand, we do not have an equivalent, equally applicable, valuation approach. Various methods are used in practice, including those based on willingness to pay to avoid premature death, wage differential approaches, and, although not economically sound, a “human capital” approach that estimates the present value of future earnings of an individual that would be lost because of premature mortality. The difficulty arises when comparing estimates between countries, especially countries with very different income levels. (For example, a common value for a “statistical life” in the United States is now $3-5 million or more; the figure is determined by income levels and willingness to pay to avoid premature death (see box 6.4). Clearly one cannot apply this same value to another country with a per capita income one-twentieth the size of that in the United States; yet deflating the U.S. value by the relative difference in income levels also ignores important dimensions, including purchasing power parity.) In the absence of carefully done national studies of the value of a statistical life, it is often best to present mortality data in terms of the number of lives lost or saved, rather than in terms of a dollar value.

Box 6.4. Valuing Life by Statistical Techniques

When loss of earnings is used to value the cost associated with premature mortality, it is referred to as the *human-capital approach.* It is similar to the change-in-production approach in that it is based on a damage function relating pollution to production, except that in this case the loss in productivity of human beings is measured. In essence, it is an ex-post, exogenous valuation of the life of a particular individual using as an approximation the present value of the lost (gross or net) market earnings of the deceased.

This approach has many shortcomings. By reducing the value of life to the present value of an individual's income stream, the human-capital approach to the valuation of life suggests that the lives of those who earn a lot are worth more than the lives of those who earn a little (and, as a direct consequence, the lives of residents of rich countries are more valuable than the lives of those in poor countries). Narrowly applied, the human-capital approach implies that the value of life of subsistence workers, the unemployed, and retirees is small or zero, and that of the underemployed is very low. The very young are also valued low, since their future discounted earnings are often offset by education and other costs that would be incurred before they enter the labor force. Furthermore, the approach ignores substitution possibilities that people may make in the form of preventive health care. In addition, it excludes nonmarket values such as pain and suffering.

At best, this method provides a first-order, lower-bound estimate of the *lost production* associated with a particular life. However, the current consensus is that the societal value of reducing risk of death cannot be based on such a value. Although most economists do not favor using this method for policy analysis purposes, it is often used to establish ex-post values for court settlements related to the death of a particular individual.

An alternative method of valuing reductions in risk of death—the wage differential approach—uses information on the "wage premium" commonly paid to individuals with risky jobs (e.g., coal miners, steel construction workers) to impute a value for an individual's implicit valuation of a statistical death. This value is found by dividing the wage premium by the increased chance of death; for example, a $100-per-year premium to undertake a job with a chance of accidental death of 1 in 10,000 is equivalent to a value of $1 million for a statistical death. Similarly, information on self-insurance and other measures also gives an indication of an individual's willingness to pay to avoid premature death.

Measuring Intangibles

21. One of the most difficult valuation areas is measuring subtle or dramatic changes in ecosystems, effects on historical or cultural sites, and recreational benefits. However, such benefits are the primary focus or important components of an increasing number of lending operations. Although difficult, it is possible, for example, to estimate economic values for the consumer surplus of visitors to parks and protected areas (see box 6.5).

22. Intangible benefits often include important environmental benefits that are secondary to the primary benefits produced by a project. Air pollution control projects in Santiago and Mexico City, for example, will yield primary benefits by reducing pollution's health effects and materials damage to buildings, equipment, and other capital goods. Cleaner air will also improve visibility, an important but unpriced benefit. Ideally, the visibility benefits should also be entered into the economic analysis, but data and measurement difficulties usually mean that these measures are entered into the analysis only in a qualitative manner.

Box 6.5. Valuing Consumer Surplus of International Tourists in Madagascar

This example presents an application of the *travel cost* and *contingent valuation* methods to estimate some of the benefits associated with the creation of a new park in Madagascar. A strong point of the study is that it used questionnaires based on two different valuation techniques to estimate consumer surplus and compare the results.

Questionnaires were prepared and administered to visitors to the small Perinet Forest Reserve adjacent to the proposed Mantadia National Park. Visitors tended to be well-off and well-educated, with an average annual income of $59,156 and 15 years of education. On average, they stayed in Madagascar for 27 days. Using data from the visitor survey, supplemented with data from tour operators, an econometric analysis was conducted to apply the travel-cost approach. Estimating demand by international tourists requires reformulating traditional travel-cost models, because people who travel to a country like Madagascar engage in a variety of activities of which the visit to the proposed national park would be only one.

The model was then used to predict the benefits to tourists (increase in consumer surplus), assuming that the Mantadia National Park will result in a 10-percent increase in the quality of local guides, educational materials, and facilities for interpreting natural areas in Madagascar. The travel-cost method produced an average increase in willingness to pay per trip of $24 per tourist. If 3900 foreign tourists visit the new park (a conservative assumption—the same number as currently visit the Perinet Reserve), the annual “benefit” to foreign tourists would be $93,600.

The contingent valuation method was also used to directly estimate the value of the proposed park for foreign tourists. Visitors to the Perinet Forest Reserve were provided with information about the new park and, using a discrete choice format, they were asked how much more they would have been willing to pay for their trip to Madagascar to visit the new national park if (a) they saw twice as many lemurs, and (b) they saw the same number of lemurs as on their current visit. Since most of these visitors are only expected to visit Madagascar once, their response represents a one-time, lump-sum payment they are willing to make in order to preserve the park. Mean willingness to pay for the park (conditional on seeing the same number of lemurs) was $65. Assuming current visitation patterns, the total annual willingness-to-pay for the park would be $253,500.

This information could then be used to help design policies to capture part of this willingness to pay and compensate nearby villagers for income lost when the establishment of the park prevented their traditional activities within the park.

Source: Kramer, Munasinghe, Sharma, Mercer, and Shyamsundar (1993); Kramer (1993).

23. In many cases, a project’s impact on the environment is not apparent, but the market value of the externality is assessable, albeit sometimes indirectly. For example, the values of houses decrease with their proximity to a highway. The highway increases the noise for nearby houses, creating a project externality that should be included in assessing the costs of the highway. The exact relationship between the highway and the level of noise may be unknown, but we can still assess the value of quiet surroundings in indirect ways. We may, for example, use information from another neighborhood on the value of houses that are close to a highway as opposed to houses that are farther away, controlling for differences in other characteristics of the properties.

Shadow Project

24. The shadow project technique equates the benefits from preserving a good with the costs of reproducing it. Take, for example, a project that requires harvesting a significant part of a mangrove forest. The shadow project techniques consists in estimating the cost of producing a new mangrove forest that would generate the same benefits as the one that will disappear, and adding the cost of the new mangrove to the project. The shadow project need not be an actual project, only a conceptual one. Obviously, this type of approach merely gives an approximation

of the cost of reproducing the mangrove forest, and not of its market value. Techniques to estimate the market value of externalities in the absence of a clear market value are discussed in Dixon, Scura, Carpenter, and Sherman (1994).

Preventing and Mitigating Environmental Impacts

25. Sometimes a project can go ahead only if the implementing agency takes measures to prevent or mitigate its environmental impact. If the impact is completely prevented, then the costs of prevention are taken into consideration in the economic and financial analysis of the project. If a factory is required to install equipment to *eliminate* air pollution, there is no environmental impact. If the factory is merely required to *mitigate* the environmental impact, the cost of the mitigating action is a direct and identifiable cost of the project, but the value of the *residual* environmental impact also needs to be considered in the costs of the project. If a dam reduces fish catch downstream despite mitigating measures, the reduction of the catch is still a cost of the project.

26. Care must be taken, however, to avoid double counting. If the favored solution to an environmental impact is to let the damage occur, tax the culprit, and then repair the damage, the cost of the project should include the environmental cost only once, either as the cost of repairing the environmental damage or as the tax (if the tax is exactly equal to the cost of repairing the environment), but not both.

Chapter 7. Cost-Effectiveness

1. Thus far we have discussed *cost-benefit analysis*, the analysis appropriate for projects whose benefits are measurable in monetary terms and whose output has a market price that is relatively easy to assess. There is a vast class of projects whose benefits either do not have a readily accessible market price or are not easily measurable in monetary terms. If the benefits of the project are measured in some nonmonetary unit, the NPV criterion for deciding whether we finance a project cannot be used. Is economic analysis useful in these cases? The answer is an unqualified yes. Economic analysis can be of great help in project design and selection. It is useful, for example, in helping select among programs that try to achieve a given result, such as choosing among several methods to improve mathematical skills. Economic analysis is also useful for selecting among methods that have multiple outcomes. For example, there might be three methods for raising reading speed, comprehension, and word knowledge. Each method may have a different impact on each of the three dimensions, and on cost. How do we choose among them? Economic analysis enables us to compare the costs of various options with their expected benefits as a basis for making choices.

2. There are two main techniques for comparing projects whose benefits are not readily measurable in monetary terms: *cost-effectiveness* and *weighted cost-effectiveness.* In all cases costs are measured as shown in the previous chapters. The main difference between the approaches is the measurement of benefits. If the benefits are measured in some single nonmonetary units, such as number of vaccines delivered, the analysis is called cost-effectiveness,. If the benefits consist of improvements in several dimensions, for example morbidity and mortality, then the several dimensions of the benefits need to be weighted and reduced to a single measure, and the analysis is called weighted cost-effectiveness.

3. The choice of technique depends on the nature of the task, the time constraints, and the information available. Cost-effectiveness is appropriate whenever the project has a single goal that is not measurable in monetary terms: for example, to provide education to a given number of children. Weighted cost-effectiveness is appropriate when the projects or interventions aim to achieve multiple goals that are not measurable in monetary terms. For example, there might be several interventions that simultaneously increase reading speed, comprehension, and vocabulary, but that are not equally effective in achieving each of the goals. Comparing among methods to achieve these aims requires that we reduce the three goals to a single measure, for which we need some weighting scheme. All evaluation techniques share some common steps: the analyst must identify the problem, consider the alternatives, select the appropriate type of analysis, and decide on the most appropriate course of action. In this chapter we provide the tools for identifying the costs and benefits and assessing whether the benefits are worth the costs.

Relating Costs to Benefits: Cost-Effectiveness Analysis

4. In cost-effectiveness analysis, the benefits are measured in nonmonetary units, such as test scores, number of students enrolled, or number of children immunized. As an example, suppose we want to evaluate the cost-effectiveness of four options to raise mathematics skills: (a) small remedial groups with a special instructor; (b) a self-instruction program supported with specially designed materials; (c) computer-assisted instruction; and (d) a program involving tutoring by

peers.[1] We first estimate the effect of each of these interventions on mathematics skills as measured, for example, by test scores, while controlling for initial levels of learning and personal characteristics. Suppose we find that students taught in small groups attain scores of 20 points, those undergoing the self-instruction program score 4 points, those with computer-assisted instruction score 15 points, and those in the peer-tutoring group score 10 points (table 7.1). These results show that small group instruction is the most *effective* intervention. But to determine the most *cost-effective* intervention we also need to take costs into account. Suppose that the cost per student is $300 for small group instruction, $100 for the self-instruction program, $150 for computer-assisted instruction, and $50 for peer tutoring. Given these costs, the most cost-effective intervention turns out to be peer tutoring: it attains one-half the gain of small group instruction at only one-sixth the cost, for a cost-effectiveness ratio of only 5 (see table 7.1). Cost-effectiveness analysis can also be used to compare the efficiency of investment in different school inputs, as shown in box 7.1.

Table 7.1. Hypothetical Cost-Effectiveness Ratios for Interventions to Improve Mathematics Skills

Intervention	*Size of effect on test scores*	*Cost per student ($)*	*Cost-effectiveness ratio*
Small group instruction	20	300	15
Self-instruction materials	4	100	25
Computer-assisted instruction (CAI)	15	150	10
Peer tutoring	10	50	5

Source: adapted from Levin (1983).

5. Cost-effectiveness ratios must always be used with caution. In the above example, peer tutoring is the most cost-effective intervention, but cost-effectiveness alone is not enough to justify an intervention. If we have several cost-effectiveness ratios and either the numerator or the denominator are exactly the same number in all cases, CE ratios can be used safely for decision making. Otherwise, one must exercise caution. In the example above, CAI produces a gain of five points over peer tutoring at an additional cost of $100, or $20 per point. To choose peer tutoring over CAI solely on the basis of CE ratios would be tantamount to saying that the marginal gain in text scores is not worth the marginal expense. When using CE ratios, analysts are well advised to ask three questions. First, can I increase the intensity of an intervention and improve the results? Second, can I combine interventions and improve the results? Third, is the marginal gain from an intervention worth the extra cost?

Cost-Effectiveness in Health

6. Cost-effectiveness is also useful in evaluating interventions that aim to improve the health of a population. Suppose that we want to design a program of immunization that would provide the maximum improvement in health for allocated program funds. The package could include only DPT (a combination of diphtheria, pertussis, and tetanus vaccines) for the child and T (tetanus toxoid) for the mother, or it could also include BCG (Bacille Calmette Guerin, used to prevent tuberculosis) for the child. Suppose that we want to examine the economic advisability of adopting a DPTT program, a BCG program, or a combined DPTT+BCG program rather than continuing

[1] This example relies on Levin (1983).

with the existing low level of immunization and treatment of morbidity for diphtheria, pertussis, and tetanus. Suppose, finally, that, having mounted a DPTT program, we want to examine the advisability of adding a BCG program and vice versa.

Box 7.1. Evaluating the Cost-Effectiveness of School Inputs in the Philippines

Concern about high dropout rates and poor student performance in elementary schools led the Philippine government to embark on a long-term plan for improvement. Under the 10-year Program for Comprehensive Elementary Education Development launched in 1982, the government invested an estimated $800 million (in 1981 prices), with support from the World Bank, in such inputs as textbooks, equipment, resource materials, staff training, and classroom facilities. In 1990 a follow-up Bank-financed project continued support for investments totaling $410 million (1990 prices) over a 4-year period. To inform the design of the future investments, Tan, Lane, and Coustère (1995) used data generated under the previous two World Bank operations to assess the cost-effectiveness of alternative inputs to improve student learning.

The authors first estimated the relation between selected school inputs and student learning using regression analysis, and then estimated the costs of the relevant inputs. The available data permitted evaluating the individual effects on student learning of workbooks, classroom furniture, class size, teacher qualification, and preschool education, controlling for variation in students' initial levels of learning and their family background, as well as for differences in classroom and school management practices. Simple division of the costs by the corresponding regression coefficients gave the desired cost-effectiveness ratios (see table below).

The results showed that in this particular case smaller classes and higher teac her qualification had no effect on student performance, and therefore could be ruled out as priorities for policy intervention. Three school inputs—workbooks, classroom furniture, and preschool education—had unambiguously positive effects on learning. Because in this case preschool education was costly, it was less cost-effective than the other two inputs.

Input[a]	*Annual cost per pupil (pesos)*	*Impact on achievement in mathematics*[b] *(in units of standard deviation)*	*Cost-effectiveness ratio* [c]
Workbooks	49	.194	253
Classroom furniture	53	.323	164
Preschool programs	250	.076	3,289

Source: Tan, Lane, and Coustere (1995).

[a] The cost of workbooks refers to the ore expensive of two options; the cost of classroom furniture was amortized assuming a lifetime of 10 years; and the cost of preschool programs reflects the cheapest of four options.

[b] Similar resluts hold for scores in Filipino.

[c] Pesos per standard deviation gain in mathematics scores.

7. Table 7.2 summarizes the incremental costs and benefits of adding an expanded program of immunization to the existing program of health services. The benefits of the project are measured in terms of the deaths prevented, as calculated from a simple epidemiological model based on the number of immunizations, the efficacy of the vaccines, and the incidence and case fatality rates of the diseases involved. The most effective alternative is a complete immunization program. A DPT-only immunization program, however, is just as cost-effective. If the budget constraint were $115 million, the most cost-effective feasible alternative would be a program of DPT immunization.

8. The limitations of basing decisions solely on CE ratios is starkly illustrated by this example. DPT can be said to be just as effective as a total immunization program, but forgoing adding the BCG program to DPT on the grounds of CE ratios alone would be tantamount to saying that the additional lives saved are not worth $2,068.

Table 7.2. Cost-Benefit Comparison of Immunization Alternatives

Alternative	*Benefits (deaths prevented)*	*Costs (US$millions)*	*Cost/benefit ratio*
DPTT only	231,900	111	478.7
BCG only	29,500	61	2067.8
DPTT + BCG	261,400	125	478.1
Existing BCG, DPTT added	231,900	64	276.0
Existing DPTT, BCG added	29,500	14	476.6

Assessing Unit Costs

9. Unit costs are useful for comparing the efficacy of interventions within countries and across countries. In education, for example, analysts often wish to know the average cost per student of a particular intervention. Calculating the unit costs of a mature intervention that has reached a steady state is the simplest of problems, as all the capital costs have already been incurred and the recurrent costs and the number of students enrolled are fairly stable. Assessing unit costs for a new intervention is more difficult because capital costs are typically higher in the initial years and enrollment, as well as graduates, are typically higher once the project is working at full capacity. It is necessary, therefore, to compare costs and benefits that occur at different points in time. The tools of economic analysis are helpful in these instances as well. Given the cost and benefit profile of the project, the analysis can discount the benefit and costs flows and compare them at a single point in time.

10. Consider, for example, the Mauritius Higher and Technical Education project. One of the purposes of the project was to increase the number of graduates coming out of the University of Mauritius and the three polytechnic schools. The investment costs, which would be distributed over five years, amounted to MR343 million (present value discounted at 12 percent). The recurrent costs would be proportional to the number of students and would rise from about MR4 million in the initial year to about MR21 million once full capacity had been reached. The discounted value of the recurrent costs over the life of the project was assessed at MR143 million. Enrollment, on the other hand, would rise slowly from 161 students in the initial years, to about 3,700 at full capacity. To assess the cost per student, the number of students enrolled throughout the life of the project was discounted at 12 percent. The discounted number of students was calculated at 13,575 students and the cost per enrolled student at US$2,048 at the then prevailing market exchange rate. Similar calculations show the cost per graduate at about US$8,700.

11. The same methodology may be used to assess the uni t costs of interventions in health, or in any project where the output is not easily measured in monetary terms. The economic logic of discounting the number of students enrolled in school is discussed in Chapter 9. For the moment, suffice it to say that what is being discounted are the benefits of the project. The number of students enrolled is a proxy for these benefits. In this sense, the procedure is in principle the same as for projects whose benefits are measurable in monetary terms.

Relating Costs to Benefits: Weighted Cost-Effectiveness

12. Sometimes project evaluation requires joint consideration of multiple outcomes—for example, test scores in two subjects—and perhaps also their distribution across population groups. In such situations, a first step is to assess the importance of each outcome with respect to a single goal. The assessment is usually a subjective judgment derived from one or many sources, including expert opinion, policymakers' preferences, community views, and so on. These subjective judgments are then translated into weights. Once the weights are estimated, the next step is to multiply each of the outcomes by the weights to obtain a single composite measure. The final step is to divide the composite measure by the cost of the options being considered. The results are called weighted cost-effectiveness ratios.

Application in Education

13. Suppose, for example, that employing better qualified teachers raises mathematics scores more than language scores, whereas reducing class size raises language scores more than mathematics scores. To evaluate the two options for improving student learning, the effect of each option on mathematics and language performance must be compared. One possibility is to apply equal weights to the gains in test scores, but if mathematics is judged to be more important than language, policymakers may prefer to weight scores differently, to reflect the relative importance of the two subjects.

14. Because there are man y dimensions of learning, the need for weighting may arise even when only one subject is involved. For example, consider the data in table 7.3, showing the effects of two strategies for improving three dimensions of reading skills as well as the weights assigned by experts to these skills on a 0-10 point scale. Assigning the weights is the trickiest part of the exercise; the rest of the calculation is mechanical. Dividing the weighted scores by the cost of the corresponding intervention gives the weighted cost-effectiveness ratio for comparing the interventions. At a cost of $95 per pupil for intervention A and $105 per pupil for intervention B, the option with the more favorable ratio is B.

Table 7.3. Weighting the Outcomes of Two Interventions to Improve Reading Skills

Category	*Weights assigned by expert opinion*	*Intervention A*[a]	*Intervention B*[a]
Reading speed	7	75	60
Reading comprehension	9	40	65
Word knowledge	6	55	65
Weighted test score[b]	-	1,215	1,395
Cost per pupil	-	95	105
Weighted cost-effectiveness ratio	-	12.8	13.3

Source: adapted from Levin 1983.

[a] The scores on each dimension of outcome are measured as percentile rankings.

[b] The weighted score is calculated by multiplying the score for reading speed, reading comprehension, and word knowledge by the corresponding weight and summing up the result. The weighted score of 1,215 for intervention A is equal to (7x75 + 9x40 + 6x55).

15. It is important to note that this procedure is meaningful only when outcomes are sco red on a comparable scale. We could not compare, say, reading speed in words per minute with reading comprehension in percentage of material understood. The reason is that the composite score would

then depend on the scale used to measure the individual scores. The *metric* must be the same for all dimensions being compared. One procedure is to express all the scores in terms of percentile rank, as in the example above. Applying the appropriate weights to the scores then provides the desired composite score.

Application in Health

16. Weighted cost-effectiveness is also useful in assessing health projects. Going back to the example considered before, the immunization interventions considered reduce morbidity as well as mortality. A given intervention might have different impacts on the reduction of these two indicators, and choosing among several interventions would require weighting morbidity and mortality in some way so as to produce a single measure of benefits. It has become increasingly common to measure and aggregate reduction in morbidity and premature mortality in terms of years of life gained.

Table 7.4. Benefits from Interventions: Years of Life Gained from Immunization Program

Category	*Mortality Years*	*Morbidity Years*	*Total*	*Gain from DPT only*	*Gain from BCG only*
Benefits	56,000	16,992,000	17,048,000	15,127,000	1,921,000
Costs (million US$)			125	111	61
Cost-effectiveness ratios			7.3	7.3	31.8

17. Table 7.4 shows the costs and benefits of three interventions with the benefits calculated in terms of healthy years of life gained, i.e., the sum of the difference between the expected duration of life without the intervention and the expected duration with the intervention, plus the expected number of years of morbidity avoided as a result of the intervention. The years of life gained from reductions in mortality and morbidity are calculated using the same epidemiological model previously applied to calculate deaths prevented by adding the computation of cases, information on average duration of morbidity, and years of life lost based on a life table.

Comparing Options with Subjective Outcomes

18. Sometimes there are no quantitative data relating interventions to outcomes. Suppose, for example, that we want to assess two options to improve performance in mathematics and reading, but have no data on test scores. The evaluator could first ask experts to assess the probability that test scores in the two subjects will rise by a given amount, say by one grade level, under the interventions being considered, and then weighting these probabilities according to the benefit of improving test scores in the two subjects. To elaborate, suppose informed experts judge the probability of raising mathematics scores to be 0.5 with strategy A and 0.3 with strategy B, and the probability of raising reading scores to be 0.5 with strategy A and 0.8 with strategy B. The information is insufficient to choose between the strategies, however, because neither dominates for both subjects. The weighted cost-effectiveness approach gets around this difficulty by asking policymakers (or other relevant audiences) to assign weights to the gain in test scores. Suppose they assign a weight of 9 (on a 0-10 scale) to a gain of one grade level in mathematics and a weight of 6 to a gain of one grade level in reading. The score for strategy A would then be 7.5 (=0.5x6 + 0.5x9) and the score of strategy B would be 9.0 (=0.3x6 + 0.8x9). If strategy A costs $375 and strategy B costs $400, then the cost-effectiveness ratio would be $50 for A and $44 for B, making B the preferred strategy.

Some Important Caveats

19. When there are quantitative data on the relation between project interventions and their outcomes, and when only a single dimension of outcomes matters, cost-effectiveness analysis offers a systematic tool for comparison. The method does not incorporate subjective judgments. When such judgments enter into measuring project outcomes, the method is called weighted cost-effectiveness analysis. The main advantage of weighted cost-effectiveness analysis is that it can be used to compare a wide range of project alternatives without requiring actual data.

20. The reliance on subjective data gives rise to important shortcomings in weighted cost-effectiveness analysis. These shortcomings relate to two questions: Who should rank the benefits of the options being considered? How should the rankings of each person or group be combined to obtain an overall ranking?

21. Choosing the right respondents is critical. An obvious group to consult are people who will be affected by the interventions. But there are other relevant groups, including experts with specific knowledge about the interventions and government officials responsible for implementing the options and managing the public resources involved. Given that the choice of respondents is itself a subjective decision, different evaluators working on the same problem almost invariably arrive at different conclusions using weighted cost-effectiveness analysis. The method is also unlikely to produce consistent comparisons from project to project.

22. The consolidation of individual rankings is also tricky. One problem is that preference scales indicate ordinal rather than cardinal interpretations. An outcome assigned a score of, say, 8 is superior to one assigned a score of 4, but it does not necessarily mean that the first outcome is twice as preferable. Another problem is that the same score may not mean the same thing to different individuals. Finally, there is the problem of combining the individual scores. Simple summation may be appealing, but as Kenneth Arrow (1963) pointed out in his seminal paper on social choice, the procedure would not be appropriate if there are interactions among the individuals so that their scores should really be combined in some other way. Because of the problems associated with interpreting subjective weights in project evaluation, weighted cost-effectiveness analysis should be used with extreme caution, and the weights be made explicit.

Chapter 8. Assessment of Education Projects

1. Education projects may have many types of components, some with benefits measurable in monetary terms and some with single or multiple benefits that are not measurable in monetary terms. In this chapter we illustrate the use of cost-benefit, cost-effectiveness, and weighted cost-effectiveness analysis for identifying the costs and benefits in education projects and assessing whether the benefits are worth the costs.[1] Table 8.1 shows the tools that are most appropriate for certain projects that are frequently implemented at various education levels.

Table 8.1. Most Appropriate Tool by Education Level and Objective of Project Component

Education level/type	*Project objective*	*Evaluation tool*[a/]
Primary, secondary	Expand coverage	CE or WCE
	Improve student test scores	CE or WCE
	Reduce recurrent costs of education	CE
Secondary (general or vocational), teacher training, vocational training	Increase supply of graduates (e.g., teachers)	CE or WCE
	Improve student test scores	CE or WCE
	Improve graduates' labor market prospects	CB
University	Improve graduates' labor market prospects	CB

Source: adapted from Psacharopoulos (1995a).

[a] CE refers to cost-effectiveness analysis, WCE to weighted cost-effectiveness analysis, and CB to cost-benefit analysis.

Categories of Project Costs

2. In education projects, as in all projects, the analyst must identify the project costs—and not merely the financial costs, but the opportunity costs for the country. In education projects, in particular, many opportunity costs may not be apparent. Identifying them is one of the most important steps in assessing education projects.

3. Education projects typically use personnel, facilities, equipment and materials, and client inputs. *Personnel* costs include full-time staff, part-time employees, consultants, and volunteers. For paid personnel, salaries are the simplest measure of the value of their time. If the pay scale does not reflect the economic costs of the services, some attempt must be made to estimate their opportunity costs. The contributions of volunteers are free. The category *facilities* designates the physical space used by the project. This category should include all of the facilities diverted to the project (classroom space, offices, storage areas, play or recreational facilities, and other building requirements), whether or not they entail actual cash payments. If land or facilities are donated, an imputed market value should be used to assess their cost, if they have an alternative use. *Equipment and materials* refers to furnishings (e.g., classroom and office furniture), instructional equipment (e.g., computers, audiovisual aids, books, scientific apparatus), and materials (e.g., tests, paper). As with the other categories, if donated materials have an alternative use, they

[1] As Annex 8A shows, economic analysis can also be used outside the project context to help determine the most effective use of funds within the education sector.

should be included as if they had been purchased, . *Client inputs* include such direct outlays as transportation to school and school uniforms, as well as the parents' time in volunteer activities for the school and the time of students. Student time often represents the bulk of client inputs in education projects. For very young children, those under 10 years of age who presumably do not work and hence do not forgo income when attending school, the opportunity cost of attending school is typically set at zero; but if they work on the family farm, for example, the value of the forgone work should be included.[2] For older children, time in school represents a real cost because the family forgoes the services of the child in household activities, in the family business, or on the farm. Where opportunities for wage employment exist, the student and the family forgo income while the child is in school. The value of forgone earnings is a cost of the project.

4. Finally, there may be other inputs not specifically mentioned in the above categories: for example, the cost of utilities, insurance charges, general maintenance of facilities and equipment, and training expenses. In general, all inputs should be identified in sufficient detail to make it possible to ascertain their value.

Organizing and Presenting the Cost Data

5. Cost data may be organized in various ways, depending on the type of analysis that needs to be performed. Most education projects involve both one-time lumpy outlays (such as those for buildings and equipment) and expenditures that recur annually after the project becomes operational (e.g., teacher salaries and other running costs). We are interested not only in project costs, but in their distribution among the participants as well. The former are relevant for assessing the overall project viability, while the latter affects the project's attractiveness to each group.

6. Table 8.2 illustrates how the data can be organized for the analysis. The costs in this table are for a hypothetical project involving the establishment of a one-year training program for 100 trainees. Column 1 identifies the various categories of project inputs; column 2 shows the total value of each input from the country's point of view; and columns 3 to 6 show the contribution from the various stakeholders.

7. A private firm donates computers valued at $5,000. Students and their families contribute labor to prepare the project site, thus lowering leasing costs by $20,000. The sponsoring agency spends $205,000 a year on salaries for staff, while parents donate the services of a part-time worker (e.g., a school counselor) valued at $5,000 a year. The cost of materials and supplies is valued at $25,200, of which $8,200 is borne by the sponsoring agency in direct purchases and $17,000 is the estimated value of donations from another private firm. All the other running costs of the project, amounting to $57,000, are borne by the sponsoring agency. Students incur $20,000 each in lost income, for a total of $200,000 for all 100 course participants (if they would all be fully employed).

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[2] Including forgone income as cost of education looks at education as an investment. Education, however, also has a consumption value. To the extent that education has a consumption value, low returns to education that only reflect the investment value of education underestimate the benefits.

Table 8.2. Sample Worksheet for Estimating Costs in Education Projects

Category (1)	*Total cost (2)*	*Cost to sponsor (3)*	*Cost to other government agencies (4)*	*Contributed private inputs (5)*	*Cost to student and family (6)*
Rental of buildings	100,000	80,000			20,000
Rental of equipment	20,000	15,000		5,000	
Personnel	210,000	205,000			5,000
Materials and supplies	25,200	8,200		17,000	
Other					
Utilities	12,000	12,000			
Maintenance	15,000	15,000			
Insurance	20,000	20,000			
Staff training	10,000	10,000			
Client time (forgone income)	200,000				200,000
Total recurrent cost	492,200	270,200		17,000	205,000
User fees		-50,000			+50,000
Other cash transfers		-26,000	+20,000	+6,000	
Net costs	612,200	289,200	20,000	28,000	275,000

Source: adapted from Levin (1983).

8. Transfer payments must also be included. Although transfer payments do not affect economic costs, they matter for calculating the costs borne by the various stakeholders in the project. In this example, a government agency defrays part of the costs by making a one-time cash transfer of $20,000 to the project sponsor. A community group contributes $6,000 annually to the sponsoring agency. Students pay $500 each in fees, for a total of $50,000 for the 100 students in the project.

Relating Costs to Benefits: Cost-Benefit Analysis

9. Investments in education generate various benefits. For simplicity we make a distinction between "in-school" and "out-of-school" benefits. The former include gains in the efficiency of the education system. The latter include improvement of the income-earning skills of the students and "externalities"—benefits that accrue to society at large beyond the project beneficiaries.

Evaluating Investments with In-School Benefits

10. The production of education services, like production in any other enterprise, involves decisions about how the services are organized and managed, and how inputs are combined. Because some choices are more efficient than others, we can quantify the benefits of investments

Box 8.1. Evaluating School Amalgamation Options in Barbados

In some villages in Barbados, the school-age population had been falling steadily, and some schools were becoming increasingly expensive to run as enrollments fell. Pupil-teacher ratios had dropped from an average of 24 in the mid-1970s to 21 by the mid-1980s. Many of the schools were housed in inadequate and crowded facilities. Amalgamating small schools would reduce running costs and improve the facilities. Cost-benefit analysis was applied to evaluate amalgamation options in the World Bank-financed Barbados Second Education and Training Project.

The calculations considered amalgamation options in a typical project village with two schools, one enrolling 240 children and the other enrolling 120 children. The options were (a) building a new school to replace the two existing schools; (b) building a new school for grades 3-6 only and using the larger of the existing schools for grades K-2; (c) expanding one of the existing schools to accommodate students from both schools; and (e) upgrading the existing facilities, using one to teach grades 3-6 and the other to teach grades K-2.

Each of the options required capital investments, but by allowing small classesto be combined they all reduced recurrent (mostly personnel) costs (albeit by different amounts) relative to the option of leaving the existing schools as they were. Building a new school, for example, would cost $692,100 for land, construction, equipment, and furniture, and would reduce the annual recurrent costs of enrolling the village children by $99,210. Assuming that buildings and equipment last 25 years, and that the new school becomes functional in the second year, the option had an NPV of $196,700 and an annual rate of return of 13.5 percent. Similar calculations for the other options allowed a ranking of their economic attractiveness. As it turned out in the project context, all the options generated positive NPVs and were therefore superior to the option of leaving the schools as they are The most attractive option involved re-using both existing facilities. When that option is not practicable, building a new school for grades K-6 would rank higher than building one only for grades 3-6.

Option	*Annual rate of return (%)*	*Net present value ($)*
1. Retain the existing schools as they are (reference option)	-	-
2. Replace the existing schools with a new one	13.5	196,700
3. Build new school for grades 3-6 and retain one existing school for grades K-2	11.5	65,500
4. Expand one of the existing schools to accommodate all the students	49.5	690,800
5. Upgrade the existing schools, using one for grades 3-6, and the other for grades K-2	70.0	532,200

Source: Details of the project can be found in World Bank (1991a).

in education according to the extent they support efficient choices. Take for example a project involving the consolidation of small primary schools in a region of the country where there are approximately 15 pupils for every teacher, compared with the national average of 30. The unit cost of education in the small schools are thus about twice the national average. If as a result of the project the pupil-teacher ratio rises to 20 on average, unit costs would have been reduced by 25 percent. The reduction in unit cost counts as a project benefit, and can be compared with the cost of school consolidation to evaluate its economic viability. This type of calculation was used to assess school amalgamation options in Barbados (see box 8.1).

11. Some education systems suffer from high rates of repetition, with the result that students take longer than normal to complete a cycle of education. The student loses time and the education system incurs higher costs because repeaters take up space that could be used for others. In this context, a project that somehow reduces repetition rates will produce savings in

Box 8.2. Cost-Benefit Analysis of School Improvement Options in Brazil

In 1980 the Brazilian government launched a major program, the Northeast Basic Education Project (EDURURAL), to improve elementary schools in an impoverished part of the country. The project cost a total of US$92 million, of which US$32 million was financed by a loan from the World Bank. Harbison and Hanushek (1992) used cost-benefit analysis to evaluate the payoffs to key components of the project. The logic is that by enhancing student achievement, the project reduces repetition and dropout rates. The result is to shorten the number of student-years it takes to reach a given grade level. Because the calculation ignores the value of higher achieving students and the cumulative effects higher up the educational pyramid, the authors describe their calculation as partial cost-benefit analysis. There are five main steps in making the estimate:

(a) Calculate the expected achievement gains associated with a one-dollar expenditure on each purchased input to be considered.
(b) Estimate the increase in promotion probability associated with the gain in achievement.
(c) Link the foregoing steps to obtain the increase in promotion probability associated with a one-dollar expenditure on each input.
(d) Compare the average number of student-years required for promotion with and without the investment, taking the difference as the savings in student-years arising from the initial dollar invested.
(e) Convert the time savings into dollars using estimates of the cost of a student-year of schooling.

Following these steps, Harbison and Hanushek (1992) show that certain investments to improve schooling conditions in northeast Brazil have dramatic payoffs (see table below). Investing in writing materials and textbooks, for example, returns as much as $4 on the dollar. The calculation is sensitive to underlying matrices of grade-to-grade promotion. Thus, in the most advantaged areas of the country, where grade progression is faster than in northeast Brazil, the returns to similar investments are correspondingly also smaller. Investing in educational software, for example, would then return only $0.52 on the dollar.

	Dollars saved per dollar of investment	
Investment	*Northeast (low income)*	*Southwest (high income)*
Software inputs (writing materials and textbooks)	4.02	0.52
Hardware inputs (facilities, furniture)	2.39	0.30
Upgrade teachers to complete primary schooling through		
Nonformal Logos inservice training	1.88	0.24
4 more years of formal primary schooling	0.34	0.04

Source: Harbison and Hanushek (1992, p. 154); see World Bank (1980) for the details on the project.
Note: Table reports only the results based on the fourth-grade sample.

recurrent costs. For example, if unit costs average $100 per student, and repetition in a student population of 200,000 drops from an average rate of 15 percent to 10 percent as a result of the project, the savings in costs would amount to a total of $1 million (= 200,000 x [.15-.10] x 100) annually. Typically, students repeat because they fail to keep up with their school work. Investments to improve the quality of teaching and school conditions often enhance learning and reduce students' need to repeat. In an economic evaluation of the project, the costs of these investments can be compared to the expected savings from lower repetition rates (see box 8.2).

Evaluating Investments with Out-of-School Benefits

12. Out-of-school benefits are those that arise after the beneficiaries of a project finish a course of study or leave a training program. The most obvious of such benefits is the gain in the beneficiaries' work productivity, as reflected in differences in pay or in farm output valued at

market prices.[3] Unlike earnings in public sector jobs, earnings in private sector jobs are especially relevant because they more closely reflect the economic value of labor. When evaluating a project from the point of view of society, we are interested in all the benefits; therefore, we look at before-tax earnings and the value of fringe benefits in the wage package (e.g., value of health insurance and retirement benefits).[4] But we are also interested in the benefits from the beneficiaries' point of view; thus we look at after-tax earnings and the value of fringe benefits. Any difference between the two values arising from taxes accrues to the government as a fiscal benefit.

13. We expect investments in education to increase people's productivity over their entire lifetime. In project evaluation it is useful to compute the present value of the increase, assessed at the time of graduation for each cohort of project beneficiaries. The calculation typically involves two steps: (a) estimating the relevant age-earnings profiles to obtain the increment in earnings at each age, and (b) discounting the stream of incremental earnings to the time of graduation using an appropriate discount rate. The first step can be accomplished by fitting a regression equation to cross-sectional data collected at one point in time. The second is a simple operation on computer spreadsheet programs.

14. As an example, consider the age-earnings profiles of high school and university graduates in Venezuela (figure 8.1). They reflect the mean incomes of people with high school and university education in each age group. They were computed using a five-year moving average to smooth the data (to remove the influence of small cells in the data, and those arising from age-misreporting, and so on). Thus, the mean earnings for those aged 30, for example, would be computed as the average of the earnings of people in the age group 28-32. Another method for obtaining the profiles is to estimate a regression equation for workers within each education group, relating each person's earnings (Y) to his or her age (A), as follows:[5]

$$Y = a + b.Age + c.(Age)^2$$

Once the function has been estimated, we can substitute different values for age into the equation to obtain the desired age-function profiles. They would be similar to those shown in the figure, but because they have been generated from a regression equation, the profiles would be smoother.

15. From the age-earnings profiles it is easy to determine by simple subtraction the incremental earnings of university graduates at each age relative to the corresponding earnings of high school graduates. The figure shows that university graduates delay entry into the labor force, but as soon as they finish their studies and obtain a job, they typically earn more than their high school counterparts, an advantage that persists over the entire working lifetime. Assessed at the time of graduation the value of the lifetime increment in earnings of a university graduate relative to a high school graduate, discounted at 10 percent, amounts to $378,213. In the cost-benefit analysis of a higher education project in Venezuela, the relevant benefit stream would be the product of this

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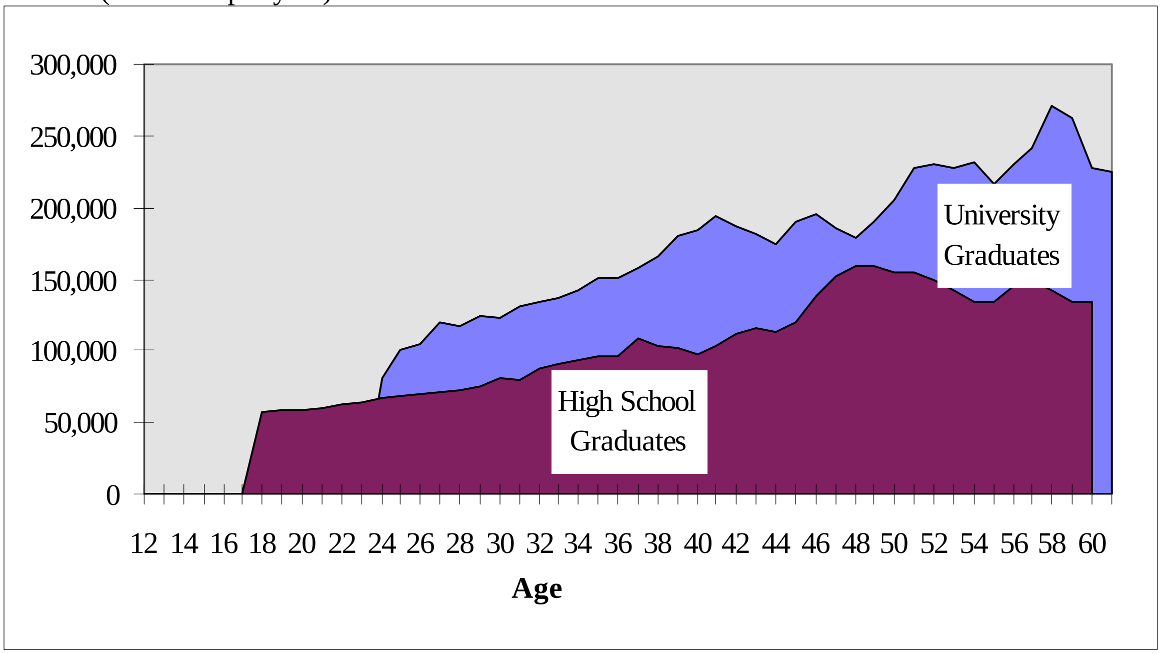
[3] Many studies show, for example, that farmers with at least four years of primary education produce more output than others with no education. The difference in outputs between the two groups of farmers, valued at market prices, can be used to estimate the economic benefits of investing in primary education. A vast literature also documents differences in the earnings of people with different levels of education (Psacharopoulos 1994a).

[4] A familiar application of the cost-benefit methodology is the computation of rates of return to different levels and types of education (see Annex 1 for details of the methodology, and Psacharopoulos 1994a for a summary of available studies). The calculation focuses on the individual student, and is useful mainly for establishing broad sectoral priorities. When applied in a project context, the method requires some modification to take into account the timing of the project's capital costs as well as the size of the investment.

[5] This equation is meant only for smoothing the data. It should be distinguished from the earnings function normally estimated that relates earnings (Y) to schooling (S) and experience (EX): $Ln (Y) = f (S, Ex, Ex^2)$.

figure and the number of university graduates that the project is expected to produce each year. The stream can be adjusted, if necessary, for differences in the projected probability of employment among university and high school graduates during their working lifetime. Because observed wages may not accurately reflect the value of student's increased productivity, it is good practice to test the sensitivity of the project's economic viability to plausible ranges in this parameter.

Figure 8.1: Age-Earnings Profiles of High School and University Graduates in Venezuela, 1989
(Bolivares per year)



16. To illustrate the mechanics of cost-benefit calculations for a project, consider a simple hypothetical investment of $80,000 to build a school (with an assumed lifetime of 25 years) for 400 secondary students, with a throughput of 100 graduates a year in the steady state (table 8.3). It takes one year to build the school, and teachers are hired as the intake rises. The student population increases from 100 students in the project's second year to 400 in its fifth year, when the school becomes fully operational. The recurrent costs (covering teacher salaries and operations) rise in tandem, from $12,000 in the second year to $48,000 a year by the fifth year, when staffing is complete. While in school each student forgoes $600 annually in income. In the third year of the project, for example, when the school has 300 students, the aggregate cost in forgone income amounts to $180,000 (= 300 x 600). Graduates from the school expect to earn more income than other workers without secondary schooling The present value of the increase, assessed at the time of graduation, amounts to $4,500 per graduate. For simplicity we assume that there are no other benefits. The relevant aggregate cost and benefit streams appear in table 8.3. Using a standard computer spreadsheet software we obtain the NPV on the project ($318,000 at a discount rate of 10 percent) and its annual rate of return (15.6 percent).

Table 8.3. Hypothetical Costs and Benefits of Investing in a Secondary School
(thousands of dollars)

	Present value	Year 0	1	2	3	4	5-25
Benefits							
Increased productivity	2,616	0	0	0	0	0	450
Costs							
Construction	(80)	(80)					
Salaries and other recurrent costs	(370)	0	(12)	(24)	(36)	(48)	(48)
Forgone income	(1,848)	0	(60)	(120)	(180)	(240)	(240)
Net benefits	318	(80)	(72)	(144)	(216)	(288)	162
Memorandum items							
Graduates (discounted at 10%)	851	0	0	0	0	0	100
IRR: 15.6							
Cost per student: $2,700							

17. If the data are arranged in a spreadsheet, it is simple to test the effect of the underlying assumptions on the project's economic viability. On the cost side, we can test the effect of increases in, for example, the cost of school construction, or changes in recurrent costs arising from the use of specialized teachers to implement a new school curriculum. On the benefit side, we can alter the incremental benefits from the project according to expectations about the future productivity of secondary school graduates relative to primary school leavers. We can incorporate information on student repetition and dropout; and we can test the sensitivity of the project's viability to assumptions about the number of students who enroll in the project institution.

18. In these calculations we have assumed that the benefit stream is the product of two factors: the increase in individual productivity and the increase in the number of people whose productivity is expected to rise as a result of the project. It is typical to assume that the projected enrollment in project institutions is the right number to use in this calculation. The assumption may overstate the benefits and costs from government-sponsored projects, because it is tantamount to assuming that nobody would be trained without such projects. In other words, it is equivalent to assuming that in the "without-project" scenario, private suppliers of education services would not step in to fill the gap left by the government. As in many areas of project evaluation, assessing the without project scenario in estimating the magnitude of project benefits and costs is not easy. But the difficulties should not deter analysis from raising the question and attempting to give a reasonable answer.

19. Finally, a word about the earnings profiles to estimate project benefits in cost-benefit calculations. Labor force surveys, which are increasingly commonplace in many developing countries, offer an easy source for the cross-sectional data used to produce the age-earnings profiles. The use of such data in project evaluation assumes that the age-specific gaps in earnings between people with different educational qualifications remain stable through time. In other words, it assumes that in 40 years' time, for example, the difference in earnings between a university graduate and a high school graduate will be the same as the difference in earnings today between a university graduate and a high school graduate who are 40 years older than fresh university graduates. The assumption would underestimate the returns to university education if earnings differentials in fact widen through time—as the evidence from the United States suggests is happening.

20. Where cross-sectional data are unavailable, the evaluator can still attempt to estimate the economic value of education by spot-checking what employers are currently paying people with

different educational qualification. This approach was taken, for example, by evaluators of the World Bank-financed Mauritius Higher Education Project, as discussed in Chapter 11. The underlying assumption is that the gap in earnings between workers in different education groups is the same at all ages, and that the gap remains stable through time.

Incorporating the Value of Externalities

21. Unlike earnings, some out-of-school benefits from education accrue mostly to society as a whole rather than to individuals. Economists use various terms to refer to such benefits: "public goods," "spillover effects," or "externalities" (because they are external to the individual). Haveman and Wolfe (1984) list 20 types of benefits associated with education, including crime reduction, social cohesion, technological change, income distribution, charitable giving, and (possibly) fertility reduction. In more recent work, Haveman and Wolfe (1995) show that large social gains also accrue via the effect of parental education on children: ensuring that current parents have a high school education reduces by 50 percent the probability that their children will drop out of school and their daughters will bear children as unmarried teenage mothers; it also reduces by 26 percent their children's probability of being economically inactive as young adults.

22. Most of the social benefits associated with education have not been quantified. Thus, given the current state of knowledge in the field, it may prove difficult to incorporate these benefits in project evaluation. Summers (1992) illustrates how progress is nonetheless possible in a practical way. He estimates the value of the reduction in child and maternal mortality and in fertility associated with investment in an extra year of schooling for girls by asking how much it would cost society to achieve the same results through other means. Summers concludes that the benefit of giving 1,000 Pakistani girls an extra year of education amounts to $88,500 and that the present value of the benefits amounts to $42,000, compared to a cost of $30,000 in education (see table 8.4).

Table 8.4. Educating Girls in Pakistan: Estimating the Social Benefits of an Extra Year of Schooling for 1,000 Girls

Benefits	*Number*	*Value ($)*
Child deaths averted	60	48,000
Births averted	495	32,000
Maternal deaths averted	3	7,500
Total present value of benefits ($) (assuming a discount rate of 5% and a delay of 15 years before the benefits materialize)		42,600
Total cost of one year of schooling for 1,000 girls		30,000

Source: Summers 1992.

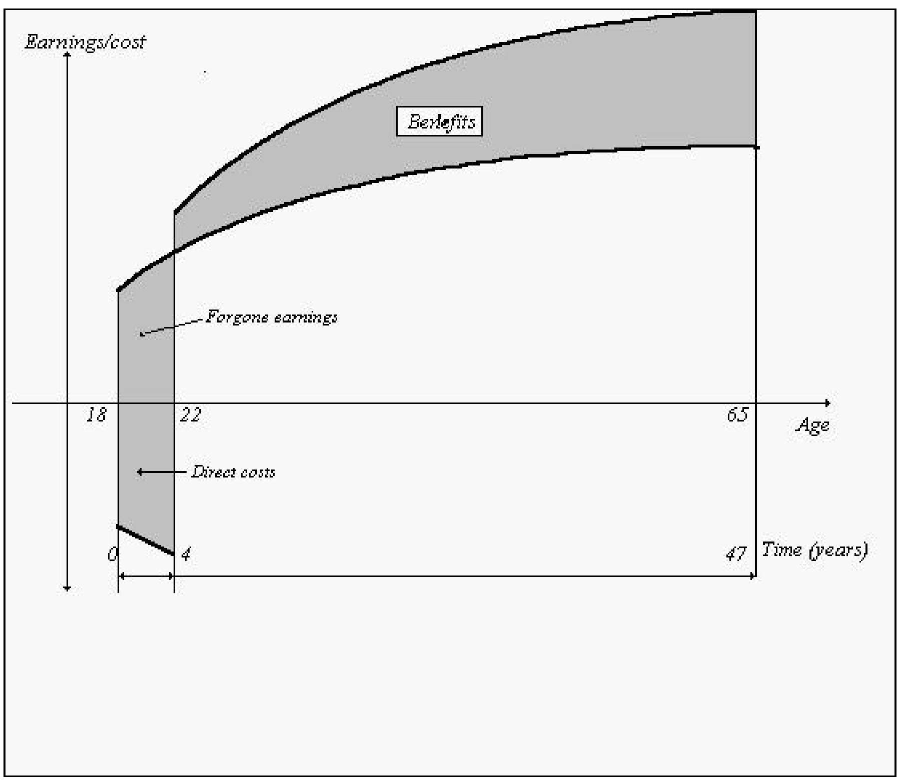
[a] Assumptions:

- Child mortality rate = 121 deaths per 1,000 live births.
- Maternal mortality rate = 600 deaths per 100,000 live births.
- Total fertility rate = 6.6 live births per woman.
- A one-year increase in female education reduces the child mortality rate by 7.5% and the total fertility rate by 7.5%.
- The cost of alternative means to avert a child death is $800, to avert a birth is $65, and to avert a maternal death is $2,500.

Annex 8A. Computing Rates of Return to Education by Level

23. In some situations analysts are interested in assessing the most effective use of funds within the education sector: will the country benefit more from investing in primary education, secondary education, tertiary education, or vocational education? To answer this question we need only data on the prevailing unit costs and age-earnings profiles of graduates at two levels of education.[6] If we are interested in the returns to university education, for example, the profiles would refer to earnings for university and high school graduates. Figure A1 shows a stylized picture of the different costs and benefits involved. Between ages 18 and 22, university graduates spend four years in college, incurring the costs of a university education (shaded area below the horizontal axis between ages 18 and 22), and forgoing the income they would have earned as a secondary school graduate (shaded area above the horizontal axis between ages 18 and 22). In addition to private costs, there are also costs to the government if university is subsidized. After graduating at age 22, university graduates begin to earn more than high school counterparts, and as the figure suggests, continue to do so until age 65 when both groups retire. The sum increment in earnings, represented by the shaded area between ages 22 and 65, is the net benefits of a university education.

Figure 8A.1. Stylized Costs and Benefits of Education



6 The method described here is an elaborate method that incorporates direct costs as well as forgone earnings in the calculation (see Psacharopoulos 1981 for a discussion of other procedures, including regression analysis).

24. The standard formula in cost-benefit analysis can be modified to the specific problem here:

$$NPV = \sum_{t=1}^{t=43} \frac{(E_u - E_s)_t}{(1+i)^t} - \sum_{t=1}^{t=4} (E_s + C_u)_t (1+i)^t$$

where E_s and E_u refer to the earnings of secondary and university graduates respectively, C_u refers to the annual unit cost of university education, and i refers to the discount rate. The index t refers to the time periods, beginning at t = 1 at age 18 and ending at t = 43 at age 65. The first term on the right-hand side is the sum of the present value incremental earnings from a university education, while the second term represents the sum of the present value of costs. The rate of return to the investment is the value of i that equates these two terms. The calculation uses individuals as the relevant unit for the assessment and ignores issues regarding the size of the proposed project (e.g., how many students it will enroll) as well as the timing of capital investments. Rates of return to education have been calculated in many countries; table A1 shows a few of these estimates for a variety of countries.

Table 8A.1. Returns to Investment in Education by Level, Latest Available Year

Country	*Primary*	*Secondary*	*Higher*
Argentina	8.4	7.1	7.6
Bolivia	9.3	7.3	13.1
Botswana	42.0	41.0	15.0
Brazil	35.6	5.1	21.4
Chile	8.1	11.1	14.0
Colombia	20.0	11.4	14.0
Costa Rica	11.2	14.4	9.0
Ecuador	14.7	12.7	9.9
El Salvador	16.4	13.3	8.0
Ethiopia	20.3	18.7	9.7
Ghana	18.0	13.0	16.5
Honduras	18.2	19.7	18.9
India	29.3	13.7	10.8
Iran	15.2	17.6	13.6
Lesotho	10.7	18.6	10.2
Liberia	41.0	17.0	8.0
Malawi	14.7	15.2	11.5
Mexico	19.0	9.6	12.9
Morocco	50.5	10.0	13.0
Nigeria	23.0	12.8	17.0
Pakistan	13.0	9.0	8.0
Papua New Guinea	12.8	19.4	8.4
Paraguay	20.3	12.7	10.8
Philippines	13.3	8.9	10.5
Sierra Leone	20.0	22.0	9.5
Somalia	20.6	10.4	19.9
South Africa	22.1	17.7	11.8
Thailand	30.5	13.0	11.0
Uganda	66.0	28.6	12.0
Upper Volta	20.1	14.9	21.3
Uruguay	21.6	8.1	10.3
Venezuela	23.4	10.2	6.2
Yemen	2.0	26.0	24.0
Zimbabwe	11.2	47.6	-4.3

Source: Psacharopoulos (1994a).

Chapter 9. Economic Evaluation of Health Projects

1. The same three basic techniques that are used to assess education projects can be used to assess health projects: in increasing order of complexity, they are cost-effectiveness analysis, weighted cost-effectiveness analysis (sometimes referred to as cost-utility analysis), and cost-benefit analysis. The greatest problems are associated with the estimation of the monetary value of benefits and hence with cost-benefit analysis. Analysts should use the simplest technique possible to address the problem at hand: cost-effectiveness where possible and weighted cost–effectiveness and cost–benefit analysis only where they are needed for intersectoral comparisons or for assessing projects with several measurable objectives (for example, gains from economic efficiency in one component and gains in health status in another). Table 9.1 shows the recommended tool for different classes of problems.

Table 9.1. Increasing Complexity of Economic Analysis in Health with Increasing Scope of Choice

Scope of comparisons (in increasing order of complexity)	*Best choice of analytical tool*	*Examples*
Single intervention Single disease Single age group	Cost-effectiveness, when definition of effects is narrow	Tuberculosis therapy Measles immunization Family planning methods
Multiple interventions Multiple diseases Single age group	Broader definition of effects: weighted cost-effectiveness (cost-utility) analysis	Child health program EPI (immunization)
Multiple interventions Multiple diseases Multiple age groups		Formulation of primary health care programs, public health strategy
Alternative delivery systems and interventions across the sector		PHC vs. hospitals Preventive vs. curative, lower- vs. upper-level services
Health sector investments compared to investments in other sectors Complex project objectives	Must use cost-benefit analysis	Education vs. health Health vs. agriculture Industry project with both health status and economic efficiency objectives

The Steps of Economic Analysis

2. For health projects, as for any other kind of project, the analyst needs to define the objectives of the analysis and the alternatives to be evaluated, including the without-project alternative. For each alternative, the analyst identifies the costs—that is, the *incremental* opportunity costs of the project. Costs should include capital costs, such as expenditures for plant, equipment, and training; recurrent expenditures, including the incremental costs of administrators, doctors, nurses, laboratory technicians, unskilled support, and other staff; and indirect costs such as patients' time and travel. An imputed annual capital cost or rent should be included for existing equipment and buildings whose use will be diverted to the project, and the donated time of community health workers or others should be given an imputed cost, as mentioned in Chapter 8. Client costs should include the opportunity cost of travel and waiting time and out-of-pocket expenditures for food, supplies, and travel.

3. Training introduces some subtleties that require care in costing. Training adds to the value of human capital, and initial training of trainers is clearly a capital expenditure. However, skills deteriorate (through obsolescence, disuse, attrition) and require maintenance and replacement. To prevent loss of skills, it is important to provide for periodic training. Training costs, therefore, should contain an important recurrent component.

4. Often health services are produced jointly and it is difficult to identify the individual costs of separate interventions, let alone the incremental costs. If the application of resources to the production of services is mutually exclusive, then the costs can be allocated across services using a criteria such as time allocation of service workers. For example, it is not possible to use staff time to do prenatal care if the time is used for surgery. The full disaggregation of costs can be complex, especially if accounting records are not kept with functional allocations in mind, but recent experiences demonstrate that it can be done. Hospitals and other facilities present a particularly difficult problem, but a procedure termed *step-down,* or *cost-center, analysis* has been developed for facility cost analysis.[1] If it is not possible to disentangle the joint costs, the analysis can evaluate the intervention alternatives first separately then together, examining the marginal cost of adding strategic combinations of the interventions in a stepwise fashion. The rest of this chapter shows the application of these concepts to an actual example, proceeding from the simplest to the more complex analytical techniques.

An Immunization Example

5. The example elaborated here is a child immunization program. The objective is to evaluate alternative immunization strategies and design a program that will provide the maximum improvement in health for a given budget. The baseline alternative is to continue with the existing low level of immunization and treatment of morbidity for diphtheria, pertussis, and tetanus. The project entails the delivery of the Bacille Calmette Guerin (BCG) vaccine to prevent tuberculosis and the DPT (diphtheria, pertussis, and tetanus) vaccine to children, and tetanus toxoid (T) to expectant women for a period of five years. For purposes of analysis, it is presumed that the program ends after five years (of course, if the program were to be successful, it would be continued indefinitely, but for evaluation purposes it is presumed to fold after five years). We want to know whether (a) the package should include only DPT for the child and T for the mother, or (b) BCG should be added for the child? Under the project, DPT vaccinations could be delivered in two visits during the first year of life, and T vaccinations to pregnant women. In addition or instead, BCG vaccinations could be given to children entering and leaving school. First we use economic analysis to determine whether it is more cost-effective to continue

[1] See Barnum and Kutzin (1993), Chapter 3, Annex 3a.

with the status quo, which relies primarily on treatment, or adopt a DPTT program, a BCG program, or a combined DPTT+BCG program. Second, we use the tools to decide whether it is worthwhile to add a BCG program to an existing DPTT program, and vice versa. Third, we assess the economic returns to the immunization program.

Identifying and Quantifying the Effects

6. We begin by identifying the benefits of the program. The objective of health sector activities increase individual and social welfare by improving health status. To determine how the program will meet this very general objective, we must identify all of the project effects that relate to a change in welfare. In practice the problem is to select the simplest attainable measure of project effects that can be expected to change proportionally with welfare. Examining the separate steps by which project implementation brings about a change in health status can help identify simple indicators that will facilitate the comparisons among alternative projects. Three kinds of indicators—input, process, and outcome indicators— are commonly discussed.

7. In the example under consideration, the benefits could be measured variously by the disbursement of project funds for vaccines (an input indicator), the number of fully immunized children (a process indicator), the number deaths prevented (an output indicator), or the number of life years saved (also an output indicator). Input indicators are generally not used because they cannot be closely linked with the ultimate outcome on health status. If number of children effectively immunized is used as the measure of effect, the implicit assumption is that there is a causal link between effective immunization and improvement in health status. Process indicators are more often used as the only practical available measure of project achievement. Their use carries an assumption of effectiveness. Outcome measures have the advantage that they focus more directly on the objective and allow a wider scope of comparisons. For this reason, if the purpose of the analysis is to calculate the most effective mode of delivery among competing formulations of the project, it is sufficient to focus on a process indicator (e.g., the number of children effectively immunized), or a relatively simple measure of outcome (e.g., the number of deaths prevented). Annex 9A gives some suggestions for process and output indicators for selected health interventions.

8. Estimation of effects may require the use of an epidemiological model tailored to the project environment, or the transfer of results from one setting to another. Epidemiological modeling can range from simple simulations based on changes in morbidity and case fatality rates, to complex modeling simulating age-specific rates and disease-transmission processes.[2] In the particular case under consideration, the effects of the project were measured in terms of premature deaths averted, as calculated from a simple epidemiological model based on the number of immunizations, the efficacy of the vaccines, and the incidence and case fatality rates of the diseases involved.[3] The results appear in table 9.2. The number of deaths prevented in any one year have been calculated using the epidemiological model. The benefits of the project taper off after year six because the program is presumed to stop after year five.

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[2] The 1992 China Sector Report, "Long Term Issues and Options in the Health Transition," illustrates the use of a complex model linking risk behavior and chronic diseases.

[3] It should be noted that modeling is not always necessary. Where analytical resources or data are limited it may be possible to transfer results from other studies. There is a growing literature on the effectiveness of specific interventions. Much of the literature on health technology must be adapted from developed countries, but there is a substantial literature on the effects of basic interventions (e .g., prenatal care, micronutrients, breastfeeding) in the context of developing countries.

Displacement of Existing Activities

9. The immunization program is expected to displace private sector activity; therefore, the gains shown in table 9.2 are gross, not net. Without a government immunization program, 8 percent of the population purchases immunization services from private health care providers. It is estimated that, after the government introduces a free program, half of the children who would have received private immunizations would now use the government program. The net coverage of the population will not be the 80 percent coverage provided by the public immunization program, but 80 percent less 4 percent. Thus, the actual effects would be 19/20 (= 76/80) of the effects calculated in table 9.2. The totals at the bottom of table 9.2 show the adjustment to reflect net gains.

Table 9.2: Worksheet with Effect Breakdown by Year and Alternative: Premature Deaths Prevented by Immunization Program

Year from start of program	*Total premature deaths prevented*	*Premature deaths prevented, DPT only*	*Premature deaths prevented, BCG only*
Year 1	0	0	0
Year 2	17,200	16,800	400
Year 3	27,600	26,800	800
Year 4	45,500	44,200	1,300
Year 5	59,300	57,600	1,700
Year 6	73,300	71,100	2,200
Year 7	24,800	22,100	2,700
Year 8	18,800	15,400	3,400
Year 9	15,300	11,200	4,100
Year 10	10,700	5,800	4,900
Year 11	5,600	0	5,600
Year 12	4,700	0	4,700
Year 13	3,600	0	3,600
Year 14	2,500	0	2,500
Year 15	1,200	0	1,200
Discounted total	199,962	182,180	17,181
Adjusted for net gains	189,964	173,071	16,322
Percent of total	100.0%	91.4%	8.6%

Is a Life Saved Today as Valuable as a Life Saved Tomorrow?

10. Table 9.2 is constructed under the assumption that a premature death prevented today is more valuable than a premature death prevented tomorrow. This peculiar result stems from standard economic theory. Life is valuable because we enjoy it. Enjoyment today is more valuable than enjoyment tomorrow; hence, if an activity prevents enjoyment's being cut short today as opposed to tomorrow, that activity is more valuable than an activity that prolongs enjoyment in the future at the expense of enjoyment in the present. What is being discounted is not the health effect itself, but the *benefits* that the health effect generates.

11. Another reason for valuing prolongation of life in the future less than prolongation of life in the present is as follows. Suppose that a program costs $1,000 and will avert premature deaths at $10 per person. We have two options. First, we can spend $1,000 this year and avert

100 deaths, or we can invest the $1,000 for one year at, say, 3 percent and have $1,030 next year, allowing us to prolong 103 lives next year. If we value premature deaths averted in the future as much as those averted today, we will take the second option. But next year we will be faced with a similar choice and we will make a similar decision, as we would be able to save 106 lives in the third. Obviously, according to this logic, as long as we can invest the money at some positive real rate and save more lives in the future, we would rather invest than saves lives. This leads to the absurd conclusion that we should never save lives. For this reason, premature averted deaths must be discounted just like any other good.

Effectiveness

12. As table 9.2 shows, the total immunization program is the most effective in preventing premature deaths, with the DPT–only program a close second, and the BCG–only program being the least effective of all. If resources were unlimited, the total immunization program would be the preferable alternative. But because we are working within a budget constraint, we need to bring costs into the picture and identify the most cost–effective alternative.

13. Table 9.3 summarizes the present value of the incremental costs of one project alternative: adding an expanded program of immunization to the existing programs of health services. The cost categories given in column 1 are highly aggregated; each of the entries in table 9.3 represents the sum of a number of individual items in the detailed project cost tables. Column 2 shows the total cost for each expenditure category, and columns 3 to 6 give the costs borne by individual stakeholders. In the example given, the initial capital costs of the program are borne by the central government but 44 percent of recurrent costs are borne by local governments and NGOs.

Table 9.3. Sample Worksheet for Estimating Costs in Health Projects
(present value, millions of US dollars)

Category (1)	*Total cost (2)*	*Cost to central govern. (3)*	*Cost to local govern. (4)*	*NGO/ Donor grants (5)*	*Cost to users (6)*
Capital costs					
Facilities	5.4			5.4	
Equipment	16.2			16.2	
Vehicles	12.1			12.1	
Training	3.0	0.3		2.7	
Technical assistance	12.8			12.8	
Total capital costs	49.5	0.3		49.2	
Recurrent costs					
Personnel	32.7	4.0	28.7		
Supplies	34.7	29.0	5.7		
Training	1.7	1.7			
Maintenance	6.7	2.0	3.0	1.7	
Other[a]	9.1	2.7	3.4	3.0	
Client time, travel, materials	3.0				3.0
Transfers					
User fees			-1.7		1.7
Private payments			-0.4		0.4
Recurrent costs net of transfers	87.9	39.4	38.7	4.7	5.1

[a]Administration, promotion, utilities.

14. Two aspects of tables 9.2 and 9.3 merit special attention. The first aspect has to do with incremental costs and benefits. If resources are to be used efficiently, the marginal cost-effectiveness must be the same for all interventions. The use of average instead of marginal cost-effectiveness will produce the same results only if the underlying effects and costs are constant, or nearly so, over the scale of investment under consideration. Calculating incremental effects of an intervention and comparing them with the incremental costs in a cost-effectiveness analysis implicitly interprets the study results as marginal. Pushing this interpretation of what are essentially average cost estimates over a wide scale of investment can introduce a bias, however. This bias can be especially important in comparing interventions in low-mortality and high-resource countries, because the marginal cost-effectiveness of any intervention falls as the incidence of its related disease falls and the level of coverage with health services rises. In lower-resource countries, with low coverage by basic interventions, the differences between resource allocations directed by marginal and average cost-effectiveness may not be as great. Analysts should use caution in applying the results of cost-effectiveness analyses over a wide range of resource availability. Certain health interventions can be promoted as dogma, but their cost-effectiveness may diminish as health service coverage and health status improve. Special care should be taken to examine unexpected local reversals in the cost effectiveness in specific environments, especially in middle-income and upper-middle-income countries.

15. The second aspect that merits attention is the treatment of cost-recovery from patients. Cost-recovery is a reimbursement by beneficiaries of expenditures made by the immunization program. The costs of the program are the materials and labor used. User fees reimburse the government agency for those costs and hence are not an incremental program cost. If clients make informal extra payments to providers (for example, to individual nurses or doctors), these payments are also transfers and not incremental project costs. These "under-the-table" payments do not accrue to the government, however, but to government employees. Table 9.3 shows them as accruing to the government to avoid adding another column. In immunization programs, such private payments are likely to be minor. In other programs, however, private payments could be large and they should be accounted for in the analysis under a separate column.

16. Full specification of the costs for the problem entails constructing the equivalent of table 9.3 for each alternative to be compared, and for each year of the project. To keep the presentation simple, we omit the details, and in table 9.4 provide a summary of the worksheets emphasizing the time dimension and the costs of alternatives, but cutting the project off at year 5. Because the BCG and DPTT program share many costs, the costs of the program alternatives are not additive. To derive the costs for the separate alternatives each line item was considered separately. Vaccines and most supplies are clearly additive, but the cold chain (refrigerated storage and transportation equipment needed to keep vaccines from deteriorating) is a cost that would be neede d for any immunization package.

Table 9.4. Worksheet with Cost Breakdown by Year and Alternative
(millions of 1995 US dollars)

Year from start of program	*Cost of total program*	*Cost if DPTT only*[a]	*Cost if BCG only*[a]	*Cost of adding BCG to DPTT program*[b]	*Cost of adding DPTT to BCG program*[b]
Year 1	25	23	14	3	12
Year 2	27	24	15	3	12
Year 3	29	26	15	3	14
Year 4	34	31	18	3	16
Year 5	36	33	18	4	18
Discounted total (10% disc. rate)	123	112	66	13	59
Value of capital remaining at end of 5 years	13	12	13	0	1
Total costs less value of capital at end of project	110	100	53	13	58

[a] The costs of operating the two programs—DPTT and BCG—separately do not add up to the costs of the total program because many of the total costs are for shared expenditures.

[b] This column shows the cost of adding a BCG program to a pre-existing DPTT program (or conversely for column 5).

17. Over the life of the project there will be a flow of expenditures for each of the items in the table. Most of the capital expenditures occur in the first three years of the project. By the fifth year the investment is complete—a warehouse for supplies and cold chain and other equipment for the vaccines are in place, and training of trainers and initial training of providers has been completed. The discounted cost of this flow of expenditures is shown in table 9.4. The discounted costs is the critical number that will be used in the numerator of the cost effectiveness calculations.

18. The services provided under the immunization project used in this example are intended to continue after the project investment is completed. Sustaining the program requires continuing recurrent expenditures to maintain the accumulated capital stock, including human resources, and to meet other routine operating costs.

Cost-Effectiveness

19. The simplest type of cost-effectiveness relate s deaths prevented to costs. For a measure of effectiveness we can use *Years of Potential Life Gained* (YLGs), which are calculated as the difference between the expected durations of life with and without the intervention.

20. Relating benefits in terms of YLGs to cost, using the data in tables 9.2 and 9.3, we see that the total immunization program prevents about 190,000 premature deaths (as compared to the baseline) at an additional cost of $110 million, for a cost-effectiveness ratio of $579 per premature death prevented. The DPTT program is equally cost -effective ($578 per premature death prevented), while the BCG program is the least cost-effective, because it prevents a premature death at a cost of $3,247. If we were to add the BCG component to an existing DPTT, we would prevent about 16,000 additional deaths at an additional cost of $13 million ($797 per death prevented). Similarly, adding DPTT to an existing BCG program would prevent about 173,000 deaths at a cost of $58 million ($335 per death prevented).

21. YLGs are easily calculated, and they can be a useful tool in countries where data are scarce and the primary objective is to reduce mortality. However, YLGs ignore benefits stemming from reduced morbidity and hence are highly biased against interventions for chronic

diseases and other conditions with large morbidity-reducing effects. Although for large classes of diseases, especially common diseases of childhood, the morbidity-reducing effects are relatively small, a broader scope of comparisons among interventions affecting different diseases across the health sector requires a broader measure of effects that takes into account reduced morbidity and mortality.

Weighted Cost-Effectiveness

22. A measure of benefits that takes into account reduced morbidity as well as reduced mortality requires a weighting scheme for the two benefits. The simplest scheme is *Healthy Years of Life Gained* (HYLG), a measure that weights morbidity and mortality effects equally. HYLGs are the sum of the years of life gained on account of reduced mortality and morbidity, adjusted for disability (see box 9.1). Table 9.5 shows the morbidity years avoided and the years of life gained from each of the interventions in our example. For this case, the years of life gained from reductions in mortality and morbidity are calculated using the same epidemiological model previously applied to calculate deaths prevented by adding the computation of cases, information on average duration of morbidity, and years of life lost based on a life table. In any one year the morbidity benefits are equal to the days of morbidity avoided in that year. The benefits from premature deaths prevented are equal to the discounted value of the difference between the years of life that the beneficiaries would have lived with and without the project. Thus, in year seven the benefits from mortality years avoided are equal 1,222,000 years. This is the discounted value of the years of life gained in year seven on account of the project. Assessing the benefits of the project, then, involves double discounting, as the total benefits of the project (13,002,000 from premature mortality avoided) are equal to the (again) discounted value of the benefits accruing in every year. Because the project aimed to reduce infant mortality and is presumed to end in year five, most of the gains occur during the early years, when childhood diseases do the most damage.

Box 9.1. Measuring Healthy Years of Life Gained (HYLGs)

When illness strikes, the individual may (a) fully recover, (b) recover, but be disabled for some time during the rest of his/her life, or (c) die. If treatment is adopted to fight the disease, fewer individuals fall prey and individuals and society benefit from the time not lost to disease and from premature deaths averted. HYLGs measure the amount of time society gains from treatment. How do we estimate HYLGs?

Let us consider Ghana, where trypanosomiasis normally affects the population at age 15 and has a case fatality rate of 19 percent. The average age of those who die from this disease is 17. Given that in Ghana life expectancy is 61.6 years, a person who is stricken and dies loses 44.5 years of life. Since the fatality rate is 19 percent, on average we would expect to lose 8.46 years of life, or 3,088 days, if a person is stricken.

After the onset of the disease, those who die are disabled for about a year and die within two years. The time lost to disability before death is given by the time lost multiplied by the incidence of the disease: [.19 x (17-15) x (50/100) x 365.25] = 69 days.

Some of those who survive are chronically disabled. It is estimated that about 13.5 percent of the population is stricken and survives, but is chronically disabled. As a result of the illness, these people are well only 70 percent of the time. Thus, for 46.5 years, 13.5 percent of the population is disabled 30 percent of the time. This implies that 687 days are lost through chronic disability: [.135 x 46.5 x 0.3 x 365.25]. Finally, there are those who fall acutely ill, but neither die nor are chronically disabled. This proportion is equal to 100 minus the case fatality rate, minus the proportion that are chronically disabled, or 67.5 percent. Since, on average, they fall ill for 90 days, the days lost are 90 x 0.675 = 61.

The sum of these four categories results in the average number of days of healthy life lost to the community by each patient with the disease (L): 3,907 = (3,088 + 69 + 687 + 61). The annual number of days lost by the community is then given by the annual incidence of the disease (I – new cases/1000 population/year), which in this case is 5 percent. The total days lost by the community, then, is 195= (3,907 x .05). Assuming a 95 percent effective treatment with 80 percent coverage, treatment would save 148 days per 1,000 population [.95 x .80 x 195]. This methodology is appropriate when we have limited information. Other, more complex methodologies are appropriate when we have more complete information (Murray and Lopez, 1994).

$\mathbf{A_o}$ = average age at onset	**C** = case fatality rate (expressed as a percent)
$\mathbf{A_d}$ = average age at death of those who die of the disease	**Q** = percent of those affected by the disease who do not die of the disease but who are permanently disabled
$\mathbf{E(A_o)}$ = expectation of life (in years) at age A_o	**D** = percent disablement of those permanently disabled
$\mathbf{D_{od}}$ = percent disablement in the period from onset until death among those who die of the disease (i.e., D_{od} = 0 = no disablement, D_{od} = 100 = disablement equivalent to death)	**t** = average period of temporary disablement (days) among those who are affected but neither die nor are permanently disabled, multiplied by the proportion disablement of those temporarily disabled

The average number of days of healthy life lost to the community by each patient with the disease is given by:

Days lost due to:

premature deaths: *disability before death:*

$$\mathbf{L} = (C/100).[E(A_o)-(A_d-A_o)].365.25 \quad + \quad (C/100).(A_d-A_o).(D_{od}/100).365.25 \quad +$$

chronic disability: *acute illness:*

$$(Q/100).E(A_o).(D/100).365.25 \quad + \quad [(100-C-Q)/100].t$$

Let **I** = annual incidence of the disease (new cases/1000 population/year)

Then the number of days lost by the community that are attributable to the disease is

$$\mathbf{R} = LI/1000 \text{ population}$$

Source: Morrow, Smith, and Nimo (1981).

Table 9.5. Worksheet with Effect Breakdown by Year and Alternative Years of Life Gained from Immunization Program

Year from start of program	*Morbidity years*	*Mortality years*	*Total HYLGs*	*Gain from DPT only*	*Gain from BCG only*
Year 1	0	0	0	0	0
Year 2	2,300	1,120,000	1,122,300	1,095,000	27,300
Year 3	4,700	1,795,000	1,799,700	1,746,000	53,700
Year 4	8,000	2,955,000	2,963,000	2,881,000	82,000
Year 5	11,300	3,857,000	3,868,300	3,755,000	113,300
Year 6	14,800	4,765,000	4,779,800	4,635,000	144,800
Year 7	9,900	1,616,000	1,625,900	1,448,000	177,900
Year 8	6,700	1,222,000	1,228,700	1,008,000	220,700
Year 9	4,900	995,000	999,900	733,000	266,900
Year 10	2,800	694,000	696,800	379,000	317,800
Year 11	500	365,000	365,500	0	365,500
Year 12	400	305,000	305,400	0	305,400
Year 13	300	235,000	235,300	0	235,300
Year 14	200	160,000	160,200	0	160,200
Year 15	100	78,000	78,100	0	78,100
Discounted total	41,906	13,002,000	13,043,906	11,882,000	1,161,906
Adjusted total	39,810	12,351,900	12,391,710	11,287,900	1,103,810
Percent of total	0.3%	99.7%	100.0%	91.1%	8.9%
Cost-effectiveness ($/HYLG)			8.9	8.9	48.1

23. Relating these indicators of effectiveness to the costs of the interventions, we obtain the results shown in the last row of table 9.5. The effects of the project are calculated in terms of the HYLGs from the reduction in mortality and morbidity. The ranking of alternative interventions is the same as before, when we used YLGs instead of HYLGs, because in this case the mortality prevention effects swamp the morbidity prevention effects.

24. The primary effects of the immunization example are from mortality reduction because the deaths prevented are those of young children and the number of years gained from each death avoided is large. This is true for many childhood diseases, making it practical in many applications to concentrate the analysis on the more readily available mortality data. For this reason, we recommend the use of YLGs where the morbidity effects are inconsequential, and HYLGs where morbidity is important.

25. Table 9.6 presents a summary of the cost-effectiveness ratios and an additional alternative that it is instructive to examine: a program of treatment in lieu of prevention. In table 9.6, the cost per unit of effect for each of the immunization program alternatives is compared with treatment. The results of the analysis make it clear that immunization programs are highly cost-effective. For the total immunization program, the cost per death prevented from treatment is over 12 times that of immunization. The results also reveal that the addition of BCG to the program (at a cost per death prevented of US$ 797) is cost-effective compared to treatment (at a cost per death prevented of US$1,950); however it would not be cost-effective if carried out as an independent program (at a cost per death prevented of US$ 3,247). Findings similar to this have been a strong reason for the addition of vaccines to existing immunization programs. It cannot always be assumed, however, that prevention programs are superior in cost-effectiveness to treatment: prevention may be carried out on large number of individuals, many of whom

would never get the disease, while treatment, especially of low-incidence diseases, is delivered to much smaller numbers.

Table 9.6. Cost-Effectiveness of Selected Alternatives
(1995 US dollars)

Alternative	*Cost per death prevented*	*Cost per HYLG*	*Cost per death prevented by treatment*[a]
Total EPI program	579	8.9	7,200
DPTT program only	578	8.9	9,800
BCG program only	3,247	48.1	1,950
DPTT considered as an added program	335	5.2	9,800
BCG considered as an added program	797	11.8	1,950

[a] This is the weighted average of the costs of treatment of the diseases considered. The weights are the proportions of total prevented cases in each alternative.

26. There are obvious problems in using equal weights for adding reductions in mortality and morbidity—a year lost to disease is not necessarily the equivalent of a full year of life lost. To correct for this problem we, would need to weight morbidity and mortality years with unequal weights. Calculating such weights necessarily involves many subjective assumptions. This example, therefore, was built using the simplest possible assumptions. Alternative measures are discussed in the following paragraphs. In this particular example, the extra complexity would not have been warranted, as it would not have altered the primary outcome of the analysis.

27. *Disability-Adjusted Life Years Gained* (DALYs) are age-weighted HYLGs.[4] DALYs are more controversial than HYLGs because the weights, which vary by age group, are highly subjective, they cloud the interpretation of the measure, and presumably vary across cultures and social contexts. If the alternatives involve comparisons across age groups, weighting for social preferences, using a procedure similar to DALYs, is needed. For all three measures—YLGs, HYLGs, and DALYs—there are approximate methods that allow regional parameters to be adjusted to country-specific situations where data are otherwise unavailable.[5]

28. *Quality-Adjusted Life Years* (QALYs) is a measure calculated by adjusting morbid life years by subjective measures of quality where a fully functional year of life is given a weight of 1 and dysfunctional years are counted as fractions. The measure is similar to HYLGs and DALYs, both of which adjust for disability years using fractional weights. For QALYs, however, the adjustment is more explicitly linked to utility or quality-of-life status than for the other measures, which are limited to disability. QALYs are data-intensive. They have become a standard tool in cost-effectiveness analysis for technology assessment in OECD countries, especially in Europe, but standard methods of determining the weights in a developing countries have yet to be developed and tested.

Cost-Benefit Analysis

29. Putting a dollar value on the benefits of health projects makes it possible to compare them with projects in other sectors, or with otherwise disparate benefits. However, assigning a

[4] See the discussion in Barnum (1987) and Murray and Lopez (1994).

[5] See, for example, Ravicz and Griffin (1995).

monetary value to health benefits involves a great increase in complexity. There are also added dangers of unwittingly double-counting effects or including false benefits. Annex 9B gives some examples of possible benefits from health projects.

30. Conventionally, benefits in health are categorized as direct or indirect and are primarily derived from morbidity and mortality changes, added quality of services, or gains in efficiency. Direct benefits are those that can be explicitly defined by a monetary value. Examples include avoided treatment costs or gains in efficiency of service delivery. Indirect benefits are those that are nonmonetary and can only be given an implicit monetary value. Examples are avoided loss of life or ill days, and changes in service quality.

31. The immunization example can be extended to illustrate the valuation of benefits (see table 9.7). Benefits start in the second year of the project. The benefits identified are the value of life saved, both from reduced time ill and from mortality avoided, the cost of treatment avoided, and the value of family time spent in home care. In this case, data were obtained from household surveys, labor force participation surveys, and estimates of the shadow wage rate in agriculture. A year of life saved was valued at annual per capita national income—a very conservative proxy of the economic value of life as a consumption good. Lost lifetime productivity is not included, because it is implicitly incorporated in the per capita income valuation. Treatment costs include both traditional and modern medicine and are corrected for service coverage and use.

Table 9.7. Worksheet with Benefit Breakdown by Year for Total Immunization Program
(millions of US dollars)

Year from start of program	*Treatment cost avoided*	*Value of family time in care*	*Value of morbid time avoided*	*Value of mortality avoided*	*Total value of benefits*
Year 2	2	1	2	22	27
Year 3	4	1	4	40	48
Year 4	6	2	6	69	84
Year 5	8	4	9	99	120
Year 6	11	5	12	132	160
Year 7	7	3	8	78	96
Year 8	5	2	5	76	88
Year 9	4	2	4	79	88
Year 10	3	1	2	76	82
Year 11	1	0	0	65	67
Year 12	1	0	0	58	59
Year 13	1	0	0	46	47
Year 14	1	0	0	32	33
Year 15	0	0	0	16	17
Discounted total	32	13	33	480	559
Total adjusted for displacement of existing services	30	12	31	456	531
Percent of total	6%	2%	6%	86%	100%

32. As in the analysis of effects, the benefits from reduced mortality predominate. The time pattern is not materially altered from the simpler analysis restricted to effects, and the relative

benefits of BCG, DPTT, and the total program also remain approximately as they were in table 9.2 (although table 9.7 does not show this effect).

33. Table 9.8 gives the cost-benefit summary of the immunization program. The results are not shown for the individual program alternatives, but they are consistent with the cost-effectiveness analysis. Thus, if the objective is limited to the comparison of alternatives, the cost-benefit findings do not warrant the extra expense of the analysis.

Table 9.8. Cost-Benefit Analysis of Immunization Program
(millions of 1995 US dollars)

Year	*Benefits*	*Costs*	*Net benefits*
Year 1	0	25	-25
Year 2	27	27	0
Year 3	48	29	19
Year 4	84	34	50
Year 5	120	36	84
Year 6	160	-13	173
Year 7	96	0	96
Year 8	88	0	88
Year 9	88	0	88
Year 10	82	0	82
Year 11	67	0	67
Year 12	59	0	59
Year 13	47	0	47
Year 14	33	0	33
Year 15	17	0	17
Present value (at 10% disc. rate)	559	116	443
Internal rate of return (IRR) = 98%			

34. However, cost-benefit analysis makes it possible to calculate the net benefits or IRR for the immunization program. In the example, the net benefits are especially large; they demonstrate that the immunization program provides a good return on the investment and is probably more than competitive with alternatives in other sectors. The immunization pr ogram gives net benefits of US$443 million with an IRR of 98 percent. This example gives especially dramatic results. Generally, such results can be expected from low cost programs, such as immunization, having large mortality effects on children in countries with high infant and child mortality rates.

35. There are many opportunities to add extra precision to the analyses in health. More explicit and detailed specification of the epidemiological model underlying the estimates of effects is a frequent cause of complexity; more detailed specification of benefits is another. The addition of detail to the analysis requires careful judgment. Greater complexity is sometimes essential to capture important effects needed for a policy decision or to add convincing realism to the estimates; often, however, as in the example explored in this chapter, it does not change the conclusions. Under the time and budget constraints of project preparation, analysts must carefully weigh the costs and benefits of added complexity. Experience indicates that simplicity seldom adversely effects the analysis.

36. As a general recommendation, it is best to use the simp lest measure of effects compatible with the problem to be analyzed. Often this is a measure specific to the problem (see Annex 9A). For many applications YLG provides a common denominator for comparisons. For some applications, data are readily available and effects can be measured in HYLGs or DALYs. Use the same measure of effects for all the alternatives under examination. Epidemiological models range from the relatively simple to the extremely complex, but the answers seldom differ substantially among models. It is advisable, then, to begin with the simpler versions and introduce more complex models only as needed. Use informed judgment to avoid unneeded complications. Where statistical estimates of parameters are unavailable, published material may be a useful source of information. Parameters may be obtained either by combing the literature, using analogous results from other countries, or using expert opinion. Whatever the source, the analysis should be explicit about the assumptions and the reliability of the data It is always advisable to exploit sensitivity analysis to explore critical assumptions.

Value of Life

37. Without question, the most difficult problem in evaluating benefits is to place an indirect value on life gained through reduction in mortality and morbidity. Many techniques have been suggested: The two most prominent are the human capital approach and the willingness-to-pay approach. Under the human capital approach, improvements in health status are viewed as investments that yield future gains in productivity. Useful as this approach may be to examine the effect of health on economic output, it ignores the consumption value of health. Even after retirement, for example, life has a value.

38. Willingness to pay has become the accepted measure of the value of life. Individual willingness to pay has been estimated by implication from revealed preference studies examining earnings premiums for risky jobs or safety expenditures by consumers. These studies have all been carried out in developed countries and need to be extended to developing-country settings. Informatively, however, these studies consistently produce estimates of the value of life that are greater (usually several times greater) than the discounted present value of per capita income. Thus, in the absence of evidence from revealed preference studies in developing countries, the discounted flow of per capita income provides a highly conservative substitute estimate.

Annex 9A. Examples of Measures of Performance

Program	*Process Measures (Cost per ...)*	*Outcome Measures (Cost per ...)*
Training	MD trained Nurse trained VHW trained	
Inpatient care	Bed day Delivery Surgical procedure	Death averted Year of life gained HYLG, DALY, QALY
Outpatient or outreach care:		
General	Outpatient visit	Death averted Year of life gained HYLG, DALY, QALY
MCH	MCH visit Pregnancy monitored Child monitored Immunized child Contraceptive acceptor	Death averted, etc. (as above) Month increase in birth interval Malnourished child avoided Birth averted
Disease-specific programs: Malaria/schisto Leprosy/TB/STDs	House sprayed or hectare of water treated Case treated	Unit reduction in morbidity (slide positive rate, egg count, etc.) Death averted Year of life gained HYLG, DALY, QALY
Nutrition	Breastfed child Weaned child Supplemented person year	Death averted YLG, HLYG, DALY, etc. Unit change in malnourishment Low birth weight avoided

Annex 9B. Examples of Potential Benefits from Health Projects[6]

I. Effects of reduced morbidity on productivity

(a) fewer days lost from acute stages of illness

(i) from worker

(ii) from members of family caring for the ill

(b) fewer days of productivity temporarily reduced through either changed pace of work or failure to work

(c) fewer days of lower productivity from permanent disability

II. Effects of reduced mortality on productivity

(a) fewer worker days lost through premature death

(b) less family time lost

III. Consumption benefits

(a) increased output of unmarketed household goods (such as house repairs, woodgathering, kitchen garden, pond cultivation, homemade articles)

(b) increased leisure (note interaction of leisure and productive time use; the value of leisure time is output forgone)

(c) higher quality of life

(d) intrinsic value of life and reduced suffering

(i) to the individual

(ii) to others

IV. Greater efficiency of the school system (i.e., more efficient learning)

(a) resource saving—less wasted education expendit ure

(b) higher future productivity due to better physical and mental development

V. Reduced expenditures by household on

(a) medical care, drugs, traditional healers

(b) supplementary food (e.g., in cases of malaria and diarrhea)

VI. Other benefits

(a) externalities (example: herd effect of immunization)

(b) fertility reduction following established increase in child survival

(c) new lands (examples: outer islands of Indonesia, and malaria; Voltaic river basin, and oncho)

VII. Direct government re source savings resulting from internal efficiency improvements. (Such savings usually should not be counted as a benefit in addition to such items as those above.)

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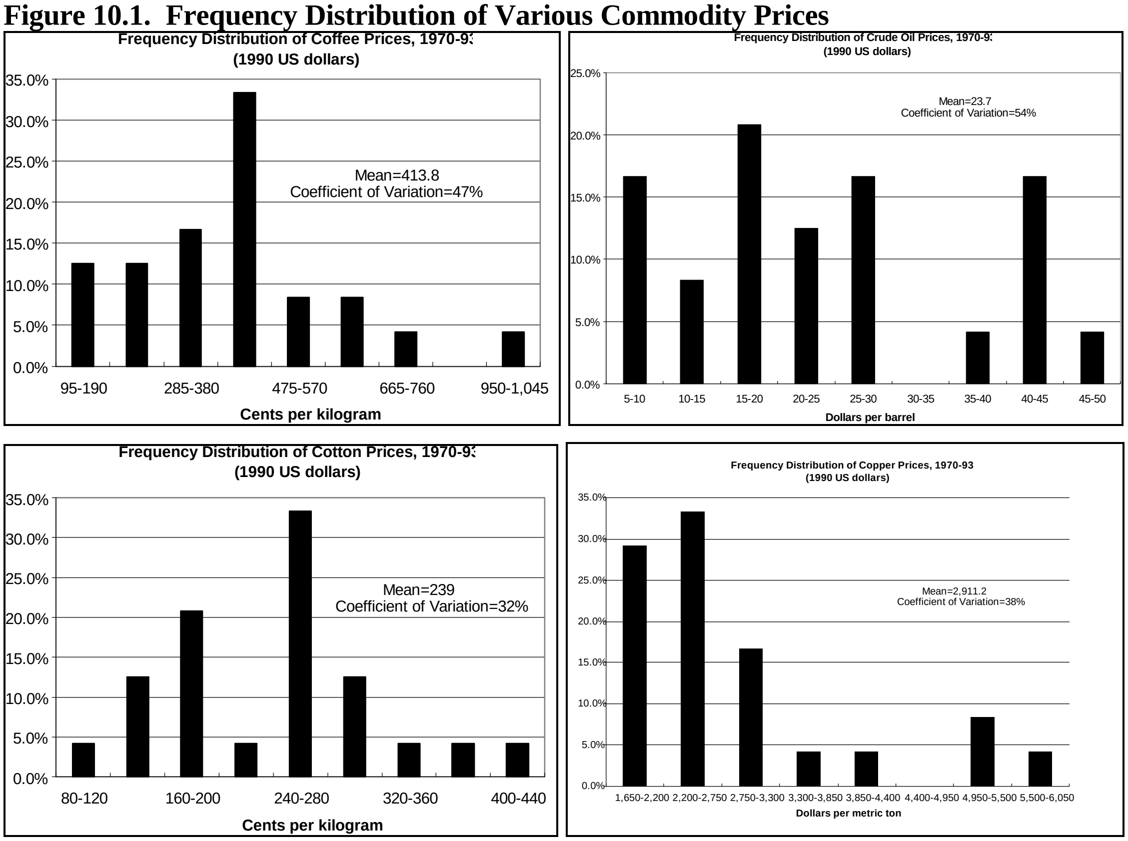
[6] Source: de Ferranti (1983).

Chapter 10. Risk and Sensitivity Analysis

1. The economic analysis of projects is necessarily based on uncertain future events. The basic elements in the cost and benefit streams of projects, such as input and output prices and quantities, seldom represent certain, or almost certain, events in the sense that they can be reasonably represented by single values. Uncertainty and risk are present whenever a project has more than one possible outcome. The measurement of economic costs and benefits, therefore, inevitably involves explicit or implicit probability judgments.

2. Take the example of someone who wants to buy coffee today, hold it for a year, and then sell. Because commodity prices are extremely variable (see figure 10.1), the outcome of this simple project is not at all certain and the person undertaking the project is taking a risk. Such a project would have made money in 12 out of the past 23 years, lost money in 10 out of 23 years, and broken even in 1 out of 23 years. If we use the past as a guide to the future, we would recognize that there are at least three possible outcomes and that each outcome has a different probability of occurring. If the project entailed the renovation of coffee plantations, added to uncertainty about coffee prices would be uncertainty about yields and costs; as a result, there would be many more possible outcomes. In this chapter we present various tools for assessing risk: sensitivity analysis, switching values, and simulation techniques.

Figure 10.1. Frequency Distribution of Various Commodity Prices



Sensitivity Analysis

3. Sensitivity analysis assesses risks by identifying the variables that most influence a project's net benefits and quantifying the extent of their influence. It consists of testing the effects of variations in selected cost and benefit variables on the project's IRR or NPV. For example, if we have a project to renovate coffee plantations and we want to identify which of two variables, coffee price or yield, is the most critical for project success, we would assess the impact on the project's NPV of varying coffee prices and yield by some arbitrary percentage, say 15 percent. Sensitivity analysis may help identify weak design options and pinpoint the need for obtaining additional information on some variables. It may also help convey some idea of project risk.

Switching Values

4. The preferred approach to sensitivity analysis uses *switching values.* The switching value of a variable is that value at which the project's NPV becomes zero (or the IRR equals the discount rate). Switching values are usually given in terms of the percentage change in the value of variable needed to turn the project's NPV equal to zero. Switching values may be useful in identifying which variables most affect project outcomes. The switching values of the relatively more important variables may be presented in order of declining sensitivity (see table 10.1).

Table 10.1. Presentation of Switching Values

Variable	*Switching value*
Yield per hectare	-25%
Construction costs	40%
Irrigated area per pump	-50%
Shadow exchange rate	60%

5. In this example, the most critical variable is yield—a decrease of more than 25 percent in the posited expected yield will make the NPV negative if other things remain as expected. If experience suggests that yield can easily be that much less than expected (perhaps because of poor-quality extension services), then this project is very risky, unless actions can be taken to prevent such a shortfall. The project's worth is also sensitive to construction costs, but a 40-percent increase in these costs (in real terms) may be considered quite unlikely if, for example, the state of engineering for the project is advanced. The table also indicates that the project's NPV is not, by itself, sensitive to the shadow exchange rate used and, therefore, fairly crude estimates of that parameter might suffice in this particular case. It is helpful to distinguish between factors that are completely beyond control, such as rainfall and world market prices, and factors that can be fully or partially controlled by project managers, such as implementation schedules and quality of extension services. Switching values of the shadow exchange rate (or other major shadow prices) should always be shown explicitly.

Selection of Variables and Depth of Analysis

6. When conducting sensitivity analysis, the analyst should normally consider three specific areas:

(a) *Aggregate costs and benefits*. Simple sensitivity analysis of the effects of variations in total project costs and total project benefits is often helpful in indicating the joint influence of underlying variables. Except in special cases, however, this type of aggregate analysis alone does not assist judgments on the range of likely variation, or on the specific measures that might reduce project risks.

(b) *Critical cost and benefit items*: Sensitivity tests are usually most effective if costs and benefits are disaggregated in some detail. While the use of subaggregates (such as "investment costs," "operating costs," etc.) can be helpful, sensitivity analysis is best done in respect of individual parameters that are most critical to the project. On the benefit side, detailed sensitivity analysis typically includes such parameters as output prices or tariff levels, unit cost savings, and expected rate of growth in demand for project outputs. On the cost side, such analysis typically involves productivity coefficients and prices of major inputs. Shadow prices used in the economic analysis should normally be examined in sensitivity analysis.

(c) *The effects of delays*. Several types of delay can occur in projects—for example, delays in starting the project, delays during the construction phase, or delays in reaching full capacity utilization (as in industrial projects) or in reaching full development (as in agricultural projects). It is normally important to include the relevant delay factors in sensitivity tests.[1]

7. While these types of analyses are likely to be useful in most cases, the amount of detail desirable in sensitivity tests may vary considerably from case to case. The analysis of delays is normally done in terms of the effects on the NPV of delays of specified time intervals (e.g., a year), although it may occasionally be useful to calculate the maximum permissible delay (i.e., its switching value). The switching value method is, however, the preferred form of analysis for other variables, especially for the detailed analysis of critical cost and benefit items.

Presentation of Sensitivity Analysis

8. Some forms of presentation of sensitivity tests are not very helpful and should be avoided. A common presentation is as follows:

Internal Rate of Return and Sensitivity Analysis (% of original estimates)

Costs	100	100	100	110	120	120
Benefits	100	90	80	100	100	80
Rate of return	30	25	20	27	22	16

This form of presentation has a number of shortcomings: it does not identify (a) the variables that most affect the variation in the IRR, or (b) the sources or types of uncertainty involved, for example, the extent to which the risk is due to factors such as construction costs and implementation schedules that can be at least partially controlled. In addition, because of the aggregate nature of such a presentation, it is difficult to judge the basis for statements that the project has a "high chance of success," or that "simultaneous adverse changes in both costs and benefits of 20 percent are very unlikely." The switching value presentation (table 10.1) is a much better way to give information about sensitivity.

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[1] The analysis of these factors is similar to the analysis of the optimum timing and time-phasing of the project, which is sometimes an important part of the economic analysis of the projects. The latter type of analysis, however, focuses on the selection of the optimal plan, while the analysis of delays refers to the delays that can occur in any given plan.

Shortcomings of Sensitivity Analysis

9. Sensitivity analysis has three major limitations: it does not take into account the probabilities of occurrence of the events; it does not take into account the correlations among the variables; and finally, the practice of varying the values of sensitive variables by standard percentages does not necessarily bear any relation to the observed (or likely) variability of the underlying variables.

10. In the example illustrated in table 10.1, the NPV of the project will turn negative if the yield per hectare declines by more than 25 percent. This information has only limited use because we do not know whether this event is highly probable or highly unlikely. If the latter, then the information is useless for all practical purposes.

11. The usual technique of varying one variable at a time, keeping the others constant at their expected values, is justified only if the variables concerned are uncorrelated; otherwise the related variables must be varied jointly. If the variables are correlated, varying only one variable at a time may lead us to conclude erroneously that a project is robust. In the same example (table 10.1), the results concerning the influence of the "irrigated area per pump" will be misleading if changes in this factor also affect the "yield per hectare realized." In fact, a 10-percent reduction in irrigated area per pump may lead to a 10-percent reduction in yield, which in turn would lead to a 60-percent reduction in NPV. Thus, the analyst should examine the sensitivity of the outcome to changes in combinations of variables that are expected to vary together—for example, variations in revenues rather than variations in price and quantity separately.

12. Finally, the practice of varying a key variable by some arbitrary percentage, say 10 percent, may cover most of the distribution for some variables, but only a minor fraction for others. Take the case of two commodity prices, the price of oranges and the price of urea. The average price of oranges during 1970-93 was $520 per metric ton (1990 prices). Seventy-five percent of the observed prices were between $450 and $550. A variation of ± 10 percent would have covered most of the observations in the period. But for urea, a commodity whose price ranged from $70 to $770 per metric ton, a similar variation would have covered only 25 percent of the observations.

13. Because of these three shortcomings, it is preferable to use techniques other than sensitivity analysis for assessing risk.

The Expected Net Present Value Criterion

14. OP 10.04, *Economic Evaluation of Investment Projects*, indicates that for projects whose benefits are measurable in monetary terms, the criterion for project acceptability is the project's *expected* NPV. In particular, the criterion requires that the project's expected NPV (a) must not be negative, and (b) must be at least as high as those of other mutually exclusive options. In most cases, this criterion is equivalent to requiring that the expected IRR exceed the opportunity cost of capital. The expected value, calculated by weighting all possible project outcomes with their corresponding relative frequencies or probabilities, takes account of the entire range of possible present values of net benefits from the project. For example, the NPV of a project that can take the following values, with their respective probabilities, is 3.2:

NPV	-6	-4	-3	-1	0	2	3	4	7	8	12
Probability	3%	4%	4%	11%	7%	11%	9%	14%	19%	7%	10%

NPV vs. "Best Estimates"

15. The NPVs and IRRs reported in Staff Appraisal Reports (SARs) are often referred to as "best estimates." Sometimes these are taken to mean "expected" values, and sometimes "most likely" values. The expected value, or mean, is not the same as the most likely value, or mode. The mode is the most frequently occurring value (or the most likely value) among all the possible values the NPV can take. Although for some statistical distributions the mode and the mean coincide, often they don't. In the example, the mode (i.e., the value with the highest probability) is 7, whereas the mean is only 3.2.

16. Unfortunately, use of modal values instead of means, seems to be somewhat common. In many cases, analysts choose the most likely values for quantities, prices, and other uncertain variables. This approach may lead to wrong decisions because the sum of most likely values is not always the most likely value of the sum. Neither is the product of most likely values the most likely value of the products. Moreover, seldom are the sums and products of most likely values the same as the expected values of the sums and of the products.

17. For example, consider a variable Benefit = Revenue - Cost, where revenue has the following probability distribution:

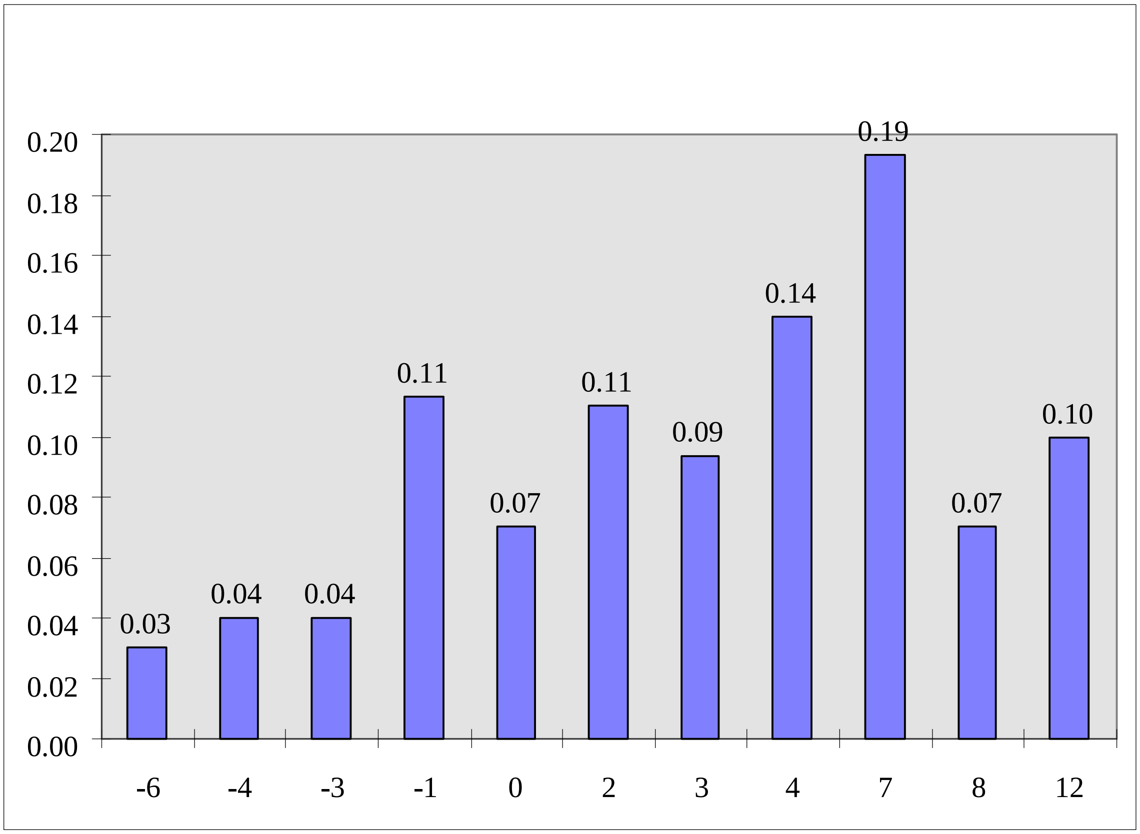
Revenue	10	12	15	16	20
Probability	3/30	4/30	6/30	7/30	10/30

and cost has the following probability distribution, assumed to be distributed independently of revenue:

Cost	8	13	16
Probability	3/10	4/10	3/10

The most likely revenue value is 20 because it has the highest probability of occurring, but the expected value is 16. For cost the most likely value is 13, and the expected value is 12.4. The new variable, Benefit, will have the distribution shown in figure 10.2.

Figure 10.2. Distribution of Benefits



The expected value is 3.6 and is equal, therefore, to the difference between the expected values of Revenues and Costs. The most likely value, however, is 7, which is not equal to the difference between the two most likely values. Consequently, the calculation of the overall modal value from individual most likely values as "best estimates" will only accidentally yield either the mean or the modal value.

Products of Variables and Interactions among Project Components

18. In the example just discussed, benefits are the result of subtracting costs from revenues. This is the simplest case encountered in estimating expected values when more than one variable is involved. Usually the relationship between the variables is more complex and involves products, ratios, and sums of ratios. For example, in many cases the variable Revenues is the product of two variables, Price and Quantity. In cases involving the product or the ratio of two variables, estimation of the expected values is more complex because the expected value of the product of two random variables is only equal to the product of the expected values if the two are statistically independent of each other. If the variables are correlated, the expected value of the product of two variables is equal to the product of the individual expected values *plus* the covariance between the two variables. If the respective standard deviations of P and Q are denoted by $S(p)$ and $S(q)$ and the simple correlation between P and Q is denoted by r, the general relation for this product of random variables is

$$E(R) = E(p)\,E(q) + r\,S(p)\,S(q)$$

where the combined final term on the right-hand side is the covariance between P and Q, i.e., cov(p,q). This can also be written in terms of the coefficient of variation, i.e., the ratio of the standard deviation to the mean: $C(X) = S(X)/E(X)$:

$$= E(p)\, E(q)\, [\, 1 + r\, C(p)C(q)\,].$$

The magnitude of the error that we introduce by ignoring the covariance depends on the degree of correlation between the two variables.

Monte Carlo Simulation and Risk Analysis

19. Proper estimation of the expected NPV of a project normally requires the use of simulation techniques. Simulation is the only simple and generally applicable procedure for overcoming the limitations of sensitivity analysis, calculating the expected NPV, and analyzing risk. Simulation usually requires more information than sensitivity analysis, but the results in terms of improved project design are worth the effort.

20. Proper estimation of the expected NPV requires three steps: specifying the probability distribution of the important uncertain components, specifying the correlations between the components, and combining this information to generate the expected NPV as well as the underlying probability distribution of project outcomes. It is generally impossible to generate the underlying distribution and calculate the expected NPV through mathematical analysis, and the analyst must rely on computer-generated simulations. Using the specified probability distributions of the uncertain project components, the computer simulates as many outcomes as the analyst wishes. In Monte Carlo simulation, the computer acts as if we were implementing the same project hundreds or thousands of times under the specified conditions. Because we assume that some of the project variables are uncertain, the simulated results are different each time. Sometimes the resulting NPV may be negative, sometimes highly positive. The computer pools the results to obtain an estimate of the average result and of its probability distribution. From the simulations, the computer generates, among other things, a probability distribution for the NPV, including the probability that the project is a failure (negative NPV), and the expected NPV. Software for performing such analysis is now widely available and readily accessible to Bank staff. Although the techniques themselves are as easy to use as estimating the NPV or IRR of a project, they do require additional information and expert judgment concerning the probability distributions of the critical project components.

Assigning Probability Distributions of Project Components

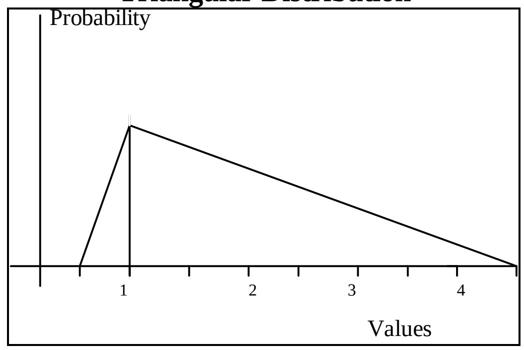
21. Assigning probability distributions of project components and specifying correlations is the most difficult step. Economic analysis needs to be based on a realistic assessment of costs and benefits, which in turn requires that the estimates of all relevant variables draw on experience in the sector and the country. Quantity forecasts need to be based on clearly identified market factors and on experience-based behavioral, technical, financial, institutional, and environmental assumptions.

22. Quantification of judgment and experience can be done at several levels of sophistication, but even a rather simplified approach is useful in project design. It is not usually necessary to consider a large number of variables. Sensitivity analysis can help identify the variables for which probability distributions should be most carefully specified. If, for example, sensitivity analysis shows that the influence of a particular variable is relatively minor, then we can treat that variable as if it were certain without introducing large errors. Also, the specification of the probability distribution for a selected variable need not be based on "hard data." For example, there may be a large sample of past observations that permits "fits" against assumed probability distributions, or there may be evidence of a more qualitative and subjective nature. The subjective judgments of experienced engineers, financial analysts, and others involved may be valuable in this context.

23. Finally, project analysts can also make simplifying assumptions about the probability distribution of variables, if the distributions are unknown. One of the simplest and most popular distributions used in empirical risk analysis is the triangular distribution. This distribution is completely described by three parameters: the most likely value (the mode), the lowest possible value, and the highest possible value. The expected value of a triangular distribution is one-third of the sum of the three parameters.

24. For example, suppose that we have a commodity and its most likely price at some future time is 1, its lowest conceivable price is 0.5, and its highest possible price is 4.5. The expected value of the triangular distribution is (0.5 + 1 + 4.5)/3 = 2. This equation may be depicted graphically in terms of a probability density function, the form of which gives this distribution its name, as in figure 10.3.

Figure 10.3. An Illustrative Triangular Distribution



25. When the probability distribution of a variable is totally unknown, tabulating historical observations in frequency histograms or frequency polygons, or their cumulative counterparts, is often a useful way of approaching the problem. Subjective judgments may help where history is no guide. For example, analysts may use the visual impact method (Anderson and Dillon 1992, pp. 41-43), in which counters (such as matches) are arranged on a chart to visually represent a person's judgment about the relative chances of occurrence of designated outcomes (discrete events or intervals of a continuous random variable), as is illustrated in figure 10.4.

Figure 10.4. Illustration of a Visual-Impact Probability Elicitation

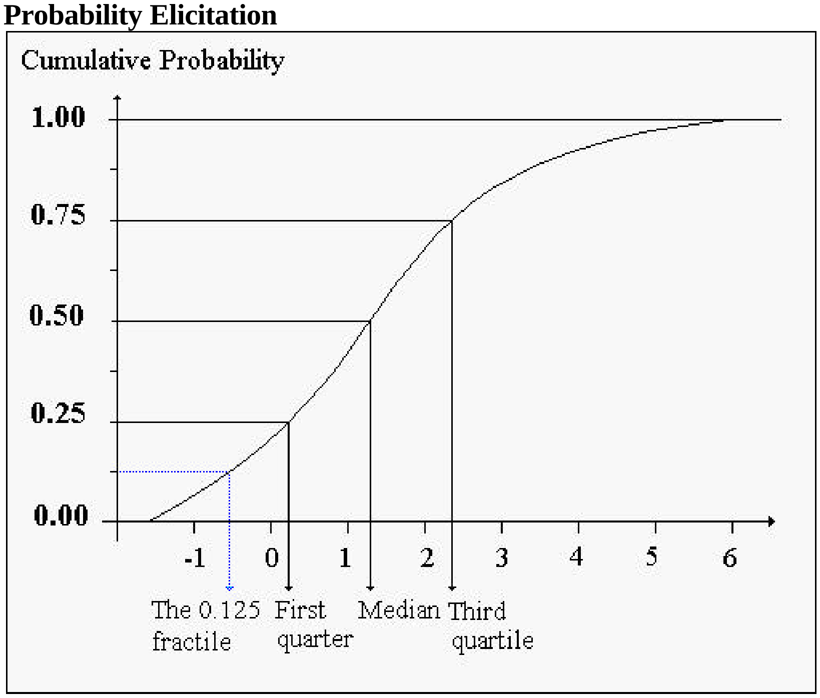
Implied probability	0/25	3/25	12/25	4/25	3/25	2/25	1/25
Visually represented frequency counters		— — —	— — — — — — — — — — — —	— — — —	— — —	— —	—
No. months	0	3	6	9	12	15	18
Project implementation delay							

26. Other methods have also been used, such as the judgmental fractile method (Raiffa 1968; Anderson, Dillon, and Hardaker 1977), in which structured questions are used to specify

subjectively the median, the quartiles, and so on, and then to sketch directly the cumulative distribution function (CDF) on which these are particular points. The results of such a process are illustrated in Figure 10.5.

27. When relevant data are available, such a purely subjective process may be aided by some form of data analysis, such as averaging past historical values. In other cases, expected values can be predicted through analysis of the structure, as is done for the price forecasts prepared by the Bank's International Economics Department. For some commodities, this is accomplished by using formal models of markets, but for others the process may devolve to simple assumptions about, for instance, the continuance of past trends. Other examples from different fields include making forecasts of expected trade flows conditional on expected growth rates in major trading-partner countries; estimating expected technical performance of power-generation facilities by combining theoretical design characteristics with expected adjustments for practical operating conditions; and assessing expected crop-yield performance by adjusting experimental controlled-conditions data by knowledge of climatic variation effects and the expected depredations of pests and diseases.

Figure 10.5. Illustration of the Judgmental Fractile Method of Probability Elicitation



Assigning Correlations among Project Components

28. After all the relevant variables have been identified and their probability distributions specified, the analyst needs to make some judgments about the covariances among the different variables. Failure to specify covariances and to take them into account may lead to large errors in judging risk. For example, in a pioneering study on use of risk analysis, Pouliquen (1970) noted that the risk of project failure was estimated at about 15 percent when two important variables—labor productivity and port capacity—were treated as independent, and at about 40 percent when their positive correlation was introduced into the analysis.

29. Variables may need to be treated jointly if, in fact, they are statistically dependent. In such a case the multivariate joint distributions involved would, in principle, need to be specified. Specification of multivariate distributions can be extremely complex, but it is seldom necessary to resort to comprehensive descriptions of statistical dependence in applied project work. Rather, pragmatic methods are readily available for imposing arbitrary levels of statistical dependence. This is usually done by specifying a rank correlation coefficient for each designated pair of variables. The individual variables can be of any specified type, and many range of types are available in commercial software: normal, triangular, beta, exponential, and so forth, as well as arbitrary continuous and discrete distributions. The final step consists of putting it all together: estimating the expected NPV and its attendant probability distribution, including the probability that the project's NPV is negative.

30. The results of the analysis can be reported in condensed form through summary statistical measures such as the expected NPV and its coefficient of variation. Analysts using such software will also naturally wish to examine the complete probability distribution of project performance, for example by depicting graphically the complete CDFs for the project's NPV.[2] One key measure that can be read directly from such CDFs is the probability that the project's NPV is less than zero. An illustration of such an analysis based on a hypothetical example using a spreadsheet-based program follows.

Advantages of Estimating Expected NPV and Assessing Risk: An Example

31. The Caneland Republic is typical of several efficient producers and exporters of sugar (extracted from cane) in that sugar is a major source of foreign exchange (about 35 percent of exports). But because the price of sugar fluctuates considerably, earnings from sugar exports are unstable, a fact that contributes to significant macroeconomic fluctuations. Gross value of sugar production constitutes about 10 percent of GDP, but this figure varies considerably (e.g., from 27 percent in 1974 to 4 percent in 1978). GDP and sugar prices are highly correlated. For a recent 21-year period, there is a simple correlation of 0.32 between the residuals from constant growth rate trends of (a) real GDP and (b) sugar output valued at the real international price (i.e., this valuation ignores domestic sugar pricing and the price realized on privileged sales to the United States and other importers).

32. The hypothetical project involves a major new sugar estate and associated infrastructure of mills, roads, and other handling facilities. When the project is fully on stream, an additional 30,000 ha. of cane will be harvested annually and, when processed, will have to be sold on the international market (within the limits agreed under the International Sugar Agreement).

33. The project has a life of 20 years. The initial outlays will amount to $200 million in the first year and $100 million in the second year. The project should begin to come on stream in the third year at 50 percent of planned capacity, and will operate at 75 percent in the fourth, before being fully operational in the fifth year and remaining so through year 21, the terminal year. Most likely, the project will begin on time (probability 0.6), but it may begin one year late (probability 0.3) or two years late (probability 0.1).

34. Once the project is implemented, the returns can be summarized by

Return = Area [Yield (Price - Ycosts) - Varcosts],

where

Area is harvested cane area, 30,000 ha. at full implementation,

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[2] See, for example, Reutlinger (1970) and Pouliquen (1970).

Price is net price, the expected value of which is $350/t,

Yield is commercial sugar harvested, the expected value of which is 10 t/ha.,

Ycosts are costs that vary proportionally to yield ($25/t), and

Varcosts are costs that vary proportionally to area ($750/ha.).

The fully implemented annual returns thus have an expected value of

75,000,000 = 30,000 [10 (350-25) - 750]

Table 10.2. Cash Flow for the Caneland Project under Conditions of Certainty and no Implementation Delays
(millions of US dollars)

Category	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Years 5-21*
Costs	200	100	75		
Benefits	0	0	37.5	56.25	75
Net benefits	-200	-100	-37.5	56.25	75
NPV @ 10% = 157; IRR = 15.9%					

35. If the project begins on time and all the variables are certain rather than random, the project's net present value (NPV) at a 10-percent discount rate is $157 million and the internal rate of return (IRR) 15.9 percent, as table 10.2 shows. A delay may occur, however, and some key variables are random. For this illustration, we assume that both yield and price are uncertain. Yields are taken to be distributed according to the triangular distribution, with lowest possible value of 8, most likely value of 9, and highest possible value of 13 tons per hectare and, thus, mean of 10 t/ha. and standard deviation 1.1/6 t/ha. We assume that price is normally distributed, with mean $350/t and standard deviation of $50/t. Unlike yields, which are independent from season to season, prices are assumed to be highly correlated over time (autocorrelated or serially correlated); this assumption is encapsulated in a simple correlation coefficient of 0.8 linking prices from year to year over the life of the project. These assumptions may be summarized in table 10.3.

Table 10.3. Key Probability Distributions of Yield and Price

Variable	*Distribution*	*Minimum*	*Most likely*	*Maximum*	*Mean*	*Std. Dev.*
Yield	Triangular	8	9	13	10	1 1/6
Price	Normal				350	50

36. The situation can be simulated with risk-analysis software attached to PC spreadsheets. Risk-analysis software permits varying the assumptions to assess the impact on the project's outcome. This example is an agriculture project whose benefits can be measured in monetary terms, but the techniques are also useful in education and health projects. The summary performance measures for several such analyses are reported in table 10.4.

Table 10.4. Outcomes and Key Assumptions

	Key assumptions				*Outcomes*	
Row	*Price*	*Yield*	*Delay*	*Correlation*	*NPV ($ million)*	*IRR (%)*
1	mean	mean	none	-	157	15.9
2	mean	mean	expected	-	131	14.8
3	mean	mode	expected	-	72	12.7
4	stochastic	stochastic	stochastic	on	130 (0.51)	14.8 (0.17)
5	stochastic	stochastic	stochastic	off	131 (0.33)	14.8 (0.11)
6	stochastic	stochastic	none	off	155 (0.39)	15.8 (0.14)

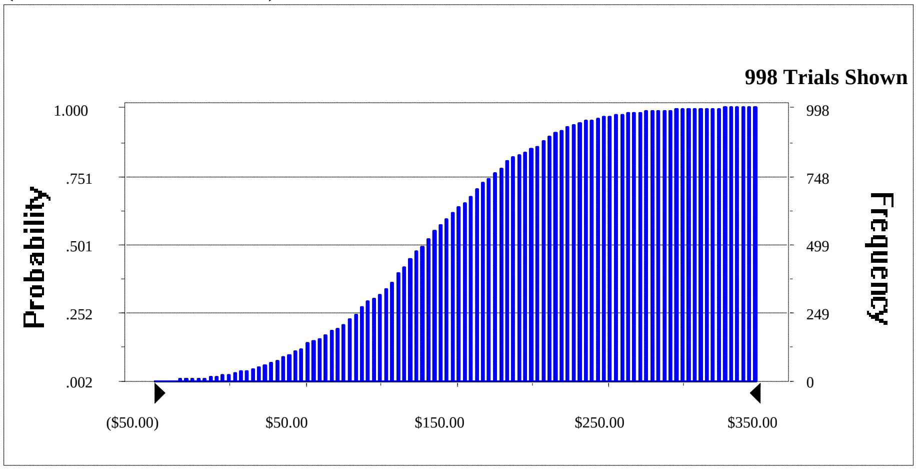
37. These few data illustrate points made earlier, including the likely overstatement of the project's NPV if risks are ignored and the analysis is worked only in terms of the expected values of the project components. Thus, if we assume that future prices and future yields will fall exactly on the mean value and that there will be no delay (row 1), then the NPV of the project will be $157 million (IRR of 15.9%). If we now factor in the possibility of a delay, then the NPV goes down to $131 million (row 2). If, in addition, we use the most likely value for the yield (modal yield), the NPV falls further to $72 million. The NPV falls because the mode is below the mean (e.g., we have a positively skewed distribution). Using the modal yield gives an unduly pessimistic estimate of the NPV of the project. This would be a case of appraisal pessimism.

38. If we use all of the information that we have available, our estimate of the NPV becomes $130 million with a coefficient of variation of 51 percent. In this instance, ignoring the serial correlations in prices (row 5) causes only a modest overstatement of the NPV but, as has been noted elsewhere, the effects of correlations may vary greatly from project to project; in some cases, ignoring correlations leads to large errors.

39. Once resources have begun to be spent on a project, speedy implementation is desirable, as delays always reduce the project's NPV. In table 10.4, row 6 shows the expected NPV taking into account all risks except delays and price correlation. The NPV is $155 million, with a coefficient of variation of 39 percent. Introducing the possibility of a delay, as row 5 shows, reduces the expected NPV to $131 million. The most complete stochastic analysis reported here is that summarized in row 4, and an alternative way to looking at it is now noted.

40. A spreadsheet-based risk analysis generates considerable additional information. One of the most useful charts, the CDF of the outcome, shows the cumulative probability that the outcome will fall below a certain value. In the Caneland project (row 4 assumptions), for example, the CDF shows that the probability of failure (negative NPV) is below 10 percent (see figure 10.6).

Figure 10.6. Cumulative Distribution Function of Project's NPV
(millions of US dollars)



41. When reporting analysis results, analysts should explicitly mention which variables are uncertain, describe the nature of the distributions and the assumptions made about their expected values, and include some commentary on how such expected values enter into overall expected values of project performance. For example, if the specification of the correlation between variables *x* and *y* is a serious issue, then the results might be presented along the following lines: "The rate of return is below the acceptable level in about 20 percent of the possible outcomes; however, this assessment is particularly sensitive to the degree of correlation assumed between the variables *x* and *y*, and the risk of failure would increase to about 40 percent if they are treated as perfectly correlated." This presentation avoids "spurious precision." The use of numerical probabilities is simply a way of expressing the uncertainties that, in the judgment of the analysts, surround the project. Analysts should also indicate the basic probability distributions of the various components of costs and benefits used, along with the necessary qualification of the results and any special difficulties encountered. It is only through transparent reporting that interested parties beyond the immediate analyst can be convinced that the analysis has been undertaken as described, and that the assumptions can be revisited for any modifications of the analysis that may subsequently be required.[3]

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[3] Such discussion is extremely rare in existing documents. One recent good example is the analysis (based on Monte Carlo methods) reported in the Appendix 10 (para. 2.10) of Baluchistan: Natural Resource Management Project (8PAKPA274). Another good example (based on complete enumeration, and weighting by discrete probabilities) is given in Annex I (part VI) of Mexico: On-Farm and Minor Irrigation Networks Improvement Project (SAR No. 12280-ME), and described in Box 10.1. The most transparent and complete economic and risk analysis is the Mauritius Higher and Technical Education Project. This project is also remarkable for the use of NPV in an education project.

Box 10.1. Mexico—Probabilistic Risk Analysis

Economic Setting: Two prongs of Mexico's current strategy in the agriculture sector are to reduce government involvement and eliminate protectionism. This project assists in the transition to a more market-based agriculture system by targeting improvements in private investments in the irrigation subsector.

Project Objectives: The Mexico On-Farm and Minor Irrigation Networks Improvement Project seeks to improve the irrigation subsector through investments in the hydraulic infrastructure. This will result in water savings, better yields, and diversification into high-value crops. The long-term effect will be to increase the profitability and sustainability of irrigated agriculture, particularly important for developing new markets under NAFTA.

Project Features: The three main components supported by this project are technological support, minor network improvements, and on-farm improvements. The Bank is financing $200 million of the project's total costs of $568.8 million.

Treatment of Risk: The Project Risks section of the SAR discusses three main risks: inadequate government counterpart funds, delays in completion of studies and surveys, and farmers' unwillingness to invest in on-farm improvements because of difficulty in obtaining credit from private banks. The first two risks would result in implementation delays, and the third risk would result in a low adoption rate. The table below summarizes how these three qualitative risks are divided into two quantitative uncertainty factors (adoption rate, implementation schedule). These factors are in turn divided into high, medium, and low scenarios, and the probability of each independent event is calculated. Next, these two sets of factors are combined into all possible combinations, resulting in nine different probabilities and corresponding ERRs. The most probable scenario is a medium (realistic) rate of adoption with no delays in implementation, resulting in an ERR of 23.5% (the expected ERR is 19.3%). Even under the most pessimistic combination of events—a low adoption rate and a two-year delay in benefits—the corresponding IRR is still above the opportunity cost of capital of 12%. This type of risk analysis successfully quantifies intangible project risks and shows how various combinations of these risks affect the rate of return.

A. Probability of different events affecting the behavior of two uncertainty factors

Factors	*Probability*
First uncertainty factor	
a. adoption rates: optimistic = 100%	0.10
b. adoption rates: modal = 65%	0.50
c. adoption rates: pessimistic = 50%	0.40
Second uncertainty factor	
d. benefits: delayed 1 year	0.35
e. benefits: no delay	0.40
f. benefits: delayed 2 years	0.25

B. Results of the combination of 6 different events affecting the uncertainty factors

Combination of events	*Combined p (p*p*pz)*	*Corresp. (ERR)*	*ERRs in descending order*	*COF of p(ERR) in descending order*
a & d	0.035	26.3%	28.0%	0.040
a & e	0.040	28.0%	26.3%	0.075
a & f	0.025	24.7%	24.7%	0.100
b & d	0.175	22.0%	23.5%	0.300
b & e	0.200	23.5%	22.0%	0.475
b & f	0.125	20.6%	20.6%	0.600
c & d	0.140	13.6%	13.6%	0.760
c & e	0.160	14.6%	14.6%	0.900
c & f	0.100	12.7%	12.7%	1.000

Opportunity cost of capital = 0.12

C. Approxim, E(ERR) = 19.3% Var E(ERR) = 22.9 Standard Deviation E(ERR) = 0.63

Source: Mexico--On-Farm and Minor Irrigation Networks Improvement Project, Report No. 12280-ME

Risk-Neutrality and Government Decision Making

42. In the case of the Caneland Republic, there was a 10-percent chance that the NPV would be negative. This means that if we were to undertake the projects under similar circumstances several times, in some cases the NPV would be greater than $130 million and in some other cases it would be less than $130 million. Roughly one-tenth of the time the project would have negative

benefits, but roughly 9 times out of 10 it would have a positive NPV. On average the benefits would be $130 million. Should we be concerned with the fact that the project's outcome may be negative? In particular, if project A has an expected NPV of $100 million and a variance of $50 and project B has an expected NPV of $200 and a variance of $250, which project should a government choose? More generally, should a government decision maker be concerned by the "riskiness" of the project as measured by the variance of the outcome? If so, how can we choose between projects that have different means and different variances; that is, how can we choose between projects with varying degrees of risk?

43. The accepted view is that, save for very special cases, governments should not be concerned with the probability of failure or with the variance of outcomes. In the vast majority of cases the expected NPV is the correct criterion for accepting or rejecting projects, and government decision makers need not concern themselves with the variability, or "risk," of the outcome. The riskiness of a single project, measured by, say, the probability of failure (negative NPV) is not, by itself, a relevant consideration in project selection for a country with a large investment portfolio. Government decision makers should be "risk-neutral." They should neither prefer risk (possess the gambler's instinct) nor avert risk, but should be concerned with maximizing the expected NPV of the projects concerned.

44. The theoretical justification for this position dates back to a 1970 article by Kenneth Arrow and Robert C. Lind and is based on the concepts of "risk pooling" and "risk spreading." If a country's portfolio has many projects *whose outcomes are mutually independent*, the country need not be concerned with the variability of the NPV of a project around its expected values, as measured, for example, by the "variance" of the probability distribution of the NPV. The reason for this is that while many projects will result in lower-than-expected NPVs, others will result in higher-than-expected NPVs; if the projects are small and do not systematically reinforce each other's outcomes, then the negative and positive effects will tend to cancel out to a large extent. This is the concept of "risk pooling."

45. The other reason has to do with "risk spreading." When a government undertakes a project on behalf of the society, it effectively spreads the risks of the project over all the members of the society: the failure of any one project amounts to a small loss for any individual member of the society. When private investors undertake a project, the failure of the project could amount to a very large loss for them. Although the risk of the public and the private project may be the same, the consequences of the loss for the individuals concerned are not the same. Government involvement spreads the risks, and the potential losses for each individual become so small that it is not worthwhile to insure against them by taking risk into account.

46. Risk-neutrality does not, however, imply that project designers should not attempt to minimize project risks.[4] Actions taken to reduce risk may also increase the expected NPV. Similarly, an action that reduces the amount of the possible loss will be desirable, even if its probability of occurrence cannot be reduced. These types of actions can be identified more effectively if the probability distributions of the NPVs are examined carefully. Thus, even though the economic *decision criterion* does not usually need to take risk into account, *project design* can benefit considerably from risk analysis.

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[4] In other words, risk-neutrality does not mean license to design projects recklessly. Safeguards against such events as floods, fires, collapse of infrastructure, serious accidents, and so on, should in principle be built into the project design.

When the NPV Criterion is Inadequate

47. There are three exceptional cases in which the project's risks need to be taken into consideration not only for design purposes, but also for deciding whether to accept or reject the project. The exceptions are large projects, "correlated" projects, and projects whose benefits or costs fall disproportionately on particular groups within the country. Such projects cannot be accepted or rejected on the basis of their expected NPV without taking its variance into consideration. In theory, these special cases require a modification of the NPV criterion; in practice even in these cases the adjustments to the NPV criterion are so small that the decision to accept or reject the project will be different only in the case of projects whose NPV is close to zero.

(a) *Large Projects.* Some projects may be so large relative to the economy that they may make a significant difference to the national income—for example, the discovery and development of new mines or oil fields. For these projects, risk-neutrality may not be the appropriate posture; if there is a shortfall, the potential loss may have dire consequences, whereas if there is a windfall, the benefits may not be equally appreciated. The country should, therefore, be prepared to accept an alternative with a lower, but more certain, expected NPV.

(b) *"Correlated" Projects.* If the national income of a country fluctuates widely (because of uncertain rainfall, fluctuations in the prices of primary commodities, etc.), then a given increase in income is more valuable when the national income is lower than when it is high. Hence a project that performs better in times of distress (say, irrigation in years of low rainfall) may be preferable to another project that performs better in good times (say, fertilizer in years of good rains), even when the latter is expected to have a higher NPV.

(c) *Projects that Affect Particular Groups.* Finally, although most projects are small when compared to the country's national income, many projects are large with respect to a particular region or particular groups of people. Consequently, while better- or worse-than-expected project results may cancel out for the country as a whole, they are unlikely to do so for particular beneficiaries. Unless the country is quite indifferent as to where the impact of a project falls, the regional impact should be taken into account. The expected value rule would not adequately reflect a country's preference for a "safe" project with a lower NPV to one with a higher expected NPV entailing risks of distress for relatively poor people.

48. In these three cases the NPV criterion is not a totally adequate guide to project selection, and the project's NPV needs to be adjusted for risk to yield a risk-free equivalent NPV. If project A is a "risky" project, then its expected NPV must be higher than that of project B if it is to be as acceptable as project B; in other words, if decision makers are to accept the project, then the project must have a "risk premium." The question then becomes, How much higher must be the NPV of a project in any of the three categories if it is to be as acceptable as the NPV of an ordinary project? This is equivalent to asking, What is the risk premium that decision makers require?

49. Usually, the risk premium is small enough to be safely ignored. Consider, for example, one of the largest projects ever considered for Bank financing. Both the capital outlays and the NPV of the project (using a 10-percent discount rate) were equivalent to about 30 percent of the country's GDP. Because the project's benefits and the country's GDP depended on the weather, the benefits were presumed to be highly correlated with GDP. In short, the project was both large and "correlated." If, for the sake of illustration, we assume that the decision makers were

extremely risk-averse, the risk premium would be 11 percent of the project's NPV. For most projects, the risk adjustments are on the order of fractions of one percent.[5]

50. If for most projects we can safely ignore risk and if for those projects in which risk assessment is necessary the adjustments are relatively small, why should we do risk analysis? Risk analysis is most useful for improving project design. For this reason, it is particularly advisable during the formative stages of a project. Also, information on riskiness, even at the final stages, helps provide a cross-check on how well the project has been prepared (by comparison with projects of a similar type, for example). Unreliable data on important variables, or inadequate preparatory work, tend to make a project riskier. Moreover, even if the country should normally be risk-neutral, external sources of finance may be risk-averse; this may be an especially important consideration in the case of cofinancing by multiple donors. Finally, estimating the expected NPV of a project often requires using simulation techniques, which in turn need the information that is usually required to assess risk: proper estimation of a project's expected NPV is inextricably tied to risk assessment.

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[5] Little and Mirrlees (1974, Appendix to Chapter 15) suggested two approximate formulas based on two of the major special cases, namely, a large project case and a "correlated" case. Anderson (1994) proposed on the basis of some simulation exercises, a combination of both these formulas that automatically picks up both mutual correlation and the size-of-project effect in the following equation:

$$D = R\,C(X)\{C(X)S/2 + r\,C(Y)\},$$

where D indicates the proportional risk reduction that must be applied to the NPV of the risky project in order to obtain a "risk-adjusted" NPV, R denotes a measure of social relative risk aversion (which most authors think should be between 2 and 4 for developing countries), $C(X)$ the coefficient of variation of the project's NPV, (i.e., for ratio of the standard deviation of the project's NPV to the project's expected NPV), $C(Y)$ for the coefficient of variation of GDP, S the relative size of project measured by the expected NPV of the project relative to the expected present value of the country's GDP (discounted at the same rate as the project and for the same number of years), and r the correlation coefficient between the project's NPV and the country's GDP. If a large project's NPV is X, then its risk-adjusted NPV would be $X(1-D)$. For example, assume a risk-aversion coefficient of 2, and suppose that the project's expected NPV is $100 million, that the coefficient of variation of the project's NPV is 0.2, that the present value of expected GDP is $10 billion and that its coefficient of variation is 0.04, and that the correlation coefficient between the project and GDP is 0.25. The adjustment factor would be:

$$D = (2)(0.2)\{(0.5)(0.2)(100/10{,}000) + (0.25)(0.04)\} = 0.0044$$

and the risk-adjusted NPV would be:

$$100x(1-0.0044) = 99.66$$

or only 0.44 percent less than the non-risk-adjusted NPV.

This example illustrates two important points. First, the formula for computing a corrective deduction is simple, provided that all the component elements of the formula are readily accessible. Some of these values, such as R, can be chosen arbitrarily. Others, such as r, are more difficult to estimate, and yet others, such as the estimation of the project's expected NPV, may require careful use of Monte Carlo simulation techniques (formerly extremely difficult to use, but now readily available for use with Lotus 1-2-3, Excel, and other spreadsheet programs). The second point illustrated by the example is that the corrections are usually small.

Chapter 11. Gainers and Losers

1. A project's net stream of benefits and, hence, its NPV is based on the assumption that the project functions as designed. The extent to which this critical assumption is fulfilled depends not only on the quality of the design, but also on the incentives facing the various agents that are responsible for project implementation, and on the benefits and costs that various groups in the society are likely to derive or incur from the project. The sustainability of a project is intimately related to its financial viability and to the distribution of project benefits. If the project requires monetary transfers to be viable, it is important to estimate the magnitude and timing of the transfers. In particular, the project's fiscal impact is of crucial importance: insufficient counterpart funds is one of the common causes of unsatisfactory performance in Bank-financed projects. Moreover, groups that derive a benefit from the project will have an interest in its success, and those who lose because of it are likely to oppose it. The intensity with which gainers defend the project and losers attack it will be related to the size of the respective benefits and costs. In assessing the sustainability of a project, then, it is helpful to identify (a) the various agents that are responsible for project implementation, assessing whether each has the incentives required to make the project work as designed, and (b) the various groups that are likely to gain or lose from the project. This section provides tools that are helpful in these endeavors.

2. The starting point is the difference between economic and financial prices and economic and financial flows. These differences represent rents or monetary flows that accrue to someone other than the project entity. Taxes are monetary flows that accrue to the government, but not to the project entity. Subsidies are transfers in the other direction, from the government to the project entity. By decomposing the shadow prices used in economic analysis and showing exactly how and why financial and economic prices differ, we can identify winners and losers. The tools of economic analysis can also be used to assess the project's fiscal impact and shed light on whether the project should be a public or a private sector project, and whether it is likely to contribute to the country's welfare.

3. To illustrate how the tools of economic analysis can be used in answering these questions, we turn to two examples. The first example is a typical private sector project included to show, among other things, how the tools help us decide that the project should be in the private sector. The example also shows a good identification of the incremental benefits and costs of the project, and of its fiscal impact. The second example is based on a Bank project in the education sector and shows the application of most of the tools developed in this Handbook to a Bank case.

Dani's Clinic

4. This case illustrates how the tools of economic analysis can be used to shed light on several important questions: (a) should the project be done by the private or the public sector; (b) what is the fiscal impact of the project; (c) who is likely to support or oppose the project; and (d) does the project contribute to the welfare of society? The case is based on a real project but has been disguised to focus attention on the tools of analysis.[1]

5. The government of this particular country was considering opening a new clinic that would provide expanded health services. By providing new services that were not available in neighboring countries, Dani's Clinic would attract foreigners (shown in the analysis as export

[1] See Andreou, Jenkins, and Savvides (1991).

sales). In addition, Dani's Clinic would displace existing domestic providers (some of them private sector providers) and at the same time increase aggregate domestic demand. To simplify the exposition, we present the results of the analysis in table 11.1 in terms of the present value of the main flows, discounted at 12 percent. The financial evaluation of the project appears in the first column. The government's point of view appears in the second column. The points of view of two important groups of stakeholders, competitors and suppliers, appear in the third and fourth columns. The last column shows the viewpoint of society, that is, it shows the economic evaluation of the project.

Table 11.1. Distribution of Costs and Benefits
(thousand pesos)

Costs and benefits	*Clinic*	*Gov't.*	*Competitors*	*Suppliers*	*Total*
Local sales	5,945	0	(539)	0	5,406
Export sales	564	79	0	0	643
Total benefits	6,509	79	(539)	0	6,049
Costs					
Local inputs	(666)	0	232	40	(394)
Imported inputs	(1,890)	(178)	0	0	(2,068)
Labor	(169)	0	15	0	(154)
Electricity & fuel	(33)	0	3	3	(27)
Other services	(1,352)	(5)	123	0	(1,234)
Land, buildings, and vehicles	(792)	(32)	72	13	(739)
Income tax	(873)	823	50	0	0
Total costs	(5,775)	608	495	56	(4,616)
Net benefits	734	687	(44)	56	1,433

6. As the first column shows, the project would have a positive financial NPV. As the last column shows, its net benefits to society would be almost twice as large as those to the clinic. Where do the differences come from? The main source of difference is income taxes, which appear as transfers from Dani's Clinic to the government. The second major difference stems from trade polices. The authors of the study estimated that the economic (or shadow price) of foreign exchange was about 14 percent higher than the market rate. The divergence between the market exchange rate and the economic value of foreign exchange, as expressed by the foreign exchange premium, was due to duties on imports and subsidies on exports, which meant that for every unit of foreign exchange diverted to the project for the importation of inputs, the government would lose about 14 percent in revenues, less 4 percent recouped via import duties applicable to the project's imports:

Financial cost	*Import duty*	*Forex premium*	*Net cost to govt.*	*Economic cost*
1,890	-75.6	+254.0	178.4	2,068

7. A similar explanation applies to the fiscal losses under the items "other services" and "land, buildings, and vehicles." The fiscal income from exports also originated from the foreign exchange premium: for every unit of exports that the project would generate, the government would receive the benefit of the foreign exchange premium. The net result is that the project would have a positive fiscal impact that stems mainly from income taxes.

8. The project would affect competitors adversely because they would lose sales whose present value amounts to 539 thousand pesos. The losses in sales would be compensated for by savings in production costs, for a net loss whose present value would amount to 44 thousand pesos (because Dani's Clinic would be a more efficient producer, society would gain by shifting away from higher-cost producers). Suppliers, on the other hand, would gain from the project because of trade policies and market imperfections. At the time, local production of the inputs needed by the clinic was protected in the country, allowing local producers to charge a premium over the border price. The premium, shown as an income accruing to suppliers, was equal to the difference between the border price and the market price, times the number of units. The suppliers of "land, buildings, and vehicles" would also benefit because domestic prices for vehicles were higher than border prices on account of both import duties and monopoly profits exacted by local distributors. The differences between the market and economic costs of these items appear as income to suppliers. Finally, labor was estimated to receive the value of its marginal product; hence there was no difference between its market price and its economic price.

9. A further potential gain that does not appear in table 11.1 is consumer surplus. The introduction of Dani's Clinic would lower the market price of the services it would offer. As a result, present consumers would receive a windfall gain, as they would be able to obtain the same services at a lower price. In addition, new consumers would enjoy a surplus equivalent to the difference between what they would have been willing to pay and what they would actually pay. The authors of the study did not attempt to measure consumer surplus for two reasons. First, it was not relevant to the decision. Second, its measurement was complicated by the displacement of the demand curve as a result of the introduction of new services. This displacement could be accompanied by a shift in the slope of the demand curve that could result in an increase or a decrease of consumer surplus, depending on whether the demand curve becomes steeper or flatter.

10. Even without consumer surplus, the analysis sheds light on several important questions. First, Dani's Clinic is a good private sector project and its status as a government project needs to be questioned. Although the project has some externalities that Dani's Clinic cannot appropriate (e.g., suppliers receive rents and the government receives taxes), enough of the net benefits accrue to it to make it a viable private sector project. Second, the project has a positive fiscal impact. Third, suppliers stand to gain modestly and may be expected to support the project, but competitors are big losers and are likely to oppose the project vehemently. Finally, the project generates enough benefits to compensate losers and make everyone better off—that is, the project enhances the country's welfare.

11. Such an analysis can be extended in several ways. First, it is possible to include as many groups of stakeholders as warranted. For example, if the shadow price of labor were lower than the market price, then a "labor" column showing the implicit subsidy accruing to labor could be included. Similarly, if the project had had an environmental impact quantifiable in monetary terms, we could have added a row and included it in the costs (or benefits). We would also have needed another column showing who would have enjoyed the benefit or who would have borne the costs. Second, we could have prepared a table for each year of the project's life and shown annual instead of total flows. Annual flows would allow us to assess whether there are years with extremely negative cash flows: it is entirely possible for a project to have a positive net present value, but a highly negative cash flow during some years. Unless appropriate provisions are made to finance the project during the lean years, such cash-flow profiles can jeopardize a project's financial viability.

Republic of Mauritius: Higher and Technical Education Project[2]

12. In 1995 Mauritius was at a critical stage in its economic development. Having turned the economy from stagnation to relative prosperity during the 1980s, Mauritius was seeking to sustain rapid economic growth and become a “newly industrialized country” by the turn of the century. During the 1970s and 1980s growth had come primarily from the rapid expansion of industries—mostly labor-intensive activities, such as garments and textiles—in the export processing zone. Since the early 1990s, however, wage increases had outpaced productivity gains, eroding the country's competitiveness and straining economic performance. The foremost challenge for Mauritius was to remain competitive in world markets. In the higher-quality/higher-value segment of the market, the most important factors affecting competitiveness are product quality, speed of delivery, dependability of services, and responsiveness to changing customer preferences—factors that depend on the level of technology and the quality and education level of the labor force. In view of Mauritius’s full employment and upward pressure on wages, therefore, the country’s future growth was thought to depend on an economywide shift to more capital-intensive technologies and expanded training to equip workers with the sophisticated skills needed to accelerate the adoption of new technologies.

Project Objective and Benefits

13. The main objective of the Higher and Technical Education Project was to produce the human resources required to support a more competitive economy. By 1995, Mauritius had already achieved universal primary education, but the secondary gross enrollment ratio was only about 50 percent, and higher education enrolled 5 percent of the 18-to-25 age group (three-fifths of whom study abroad with the aid of scholarships and tax rebates) compared to 37 percent in Korea and 19 percent in Singapore. The performance of the higher education system had suffered from the absence of a coherent policy framework, poor coordination among the four institutions of higher learning (the University of Mauritius (UM) and three polytechnic schools), low-quality institutions, and a focus on certificate and diploma programs. Hence, it was unable to attract the best Mauritian students. The main objective of the project was to support the government's education sector program for higher and polytechnic education, which aimed to overcome these problems. Table 11.2 shows the increase in graduates that was expected to result from the project.

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2 The economic analysis of the project discussed here is not exactly like that in the SAR. We have extended the SAR analysis to illustrate the use of techniques that are discussed in the Handbook but that were not deemed necessary to appraise the project.

Table 11.2. Expected Increase in Graduates as a Result of the Project

Degree	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010-2020*
Undergraduate degree	0	91	147	212	238	404	436	451	581	652	713	823	897	918	918
MBA	2	2	5	8	11	15	19	23	28	33	39	46	53	61	70
Other postgraduate	5	15	17	20	22	27	30	32	34	36	38	40	42	44	47

Project Components

14. The project would strengthen the UM and polytechnic education by

- upgrading staff and facilities, thus making the institutions more attractive to Mauritian students;
- making the curriculum more relevant to national needs;
- improving links with employers to increase the marketability of graduates;
- developing a viable postgraduate education and research program to attract and retain faculty and produce new knowledge in areas strategic to Mauritius development; and
- enhancing the efficiency of the university's operations.

Alternatives Considered

15. The government considered establishing a scholarship fund and training students abroad. Taking into account the costs of tuition, room, board, and possible permanent emigration, this alternative resulted in higher costs and lower benefits than training at home. On the benefits side, the externalities associated with developing an autonomous training program were deemed extremely valuable, even though they were not assigned monetary values. For these reasons, the decision was made to improve domestic education.

Economic Analysis

16. The benefits of the project would be the incremental productivity of the additional graduates. By increasing the quantity and quality of university graduates, the project was expected to increase the productivity of the labor force. Given the country's efficient labor market and full employment situation, the appraisal team concluded that the graduates' incremental earnings would be a good measure of the value of their incremental productivity.

17. Ideally, an age-earnings profile would be used to estimate the increased productivity of the additional graduates. The appraisal team did not have access to such data, but was able to estimate the average compensation package for different types of workers at a point in time.[3] The team's findings appear in table 11.3.

[3] While using average estimates is not as desirable as using age-earnings profile, it is better than not using anything at all. Shortcuts such as this one are often necessary in project appraisal, but whenever they are used, they should be clearly documented to make it easy for the reader to follow the argument. The age-earnings profile is the type of information that is best gathered in the context of sector work, not in the context of project appraisal.

Table 11.3. Expected Compensation of Graduates by Level of Education and Opportunity Costs Incurred While in School
(Mauritius 1995 rupees per year per graduate)

Level of education	*Expected compensation after graduation*	*Opportunity costs during school*
MBA	300,000	180,000
Other postgraduate degree	240,000	180,000
Undergraduate degree	180,000	72,000
Secondary diploma	72,000	n.a.

18. The first column of table 11.3 shows, for each level of education, the expected compensation package, including fringe benefits, representing the value employers placed on the contribution of graduates to the employing firm. For every additional graduate produced by the project, then, society would gain an amount equal to the full difference between the compensation package that the student was receiving before going to school and the compensation package that the student would receive after graduation. For an MBA graduate, this would amount to 120,000 per year.

19. Assuming that on average graduates remain in the labor force for 40 years, their net contribution to society, valued at graduation, would be equal to the present value of their incremental earnings during 40 years. The benefits (B) in any one year were calculated according to the formula $B = (N)(PV[IE])(U)$, where N stands for the number graduates, $PV[IE]$ for the present value of the incremental earnings, and U for the employment rate. Discounted at 12 percent, the benefits adjusted for employment rates were estimated at MR890,328 for each university graduate, at MR989,253 for each MBA, and MR494,627 for each PhD. The yearly contribution of the project to society, then, would be equal to the present value of the incremental contribution of every graduate times the number of graduates. The benefits for the first five years of the project appear in table 11.4. As discussed in Chapter 8, the yearly benefits need to be discounted again to estimate their present value as of a common date. For example, the benefits of the graduates emerging in 1997 amount to MR89 million. These benefits would accrue in 1997; their present value in 1995 discounted at 12 percent would amount to only MR75 million. In short, the benefits have to be discounted twice. First, the individual benefits accruing through the lifetime of the graduate are discounted to the year of graduation. This amount, multiplied by the number of graduates, represents the present value of the benefits accruing to society in the year of graduation and are shown in the fourth row of table 11.4. Second, the total benefits accruing to society must be discounted back to the year in which the project is being assessed. These amounts appear in the fifth row of table 11.4. The total benefits of the project, assessed as of 1995, are equal to the sum of the quantities appearing in the fifth row summed over the life of the project. This amount is the cumulative present value of the project.

Table 11.4: Gross Project Benefits, 1995-1999
(thousand 1995 Mauritius rupees)

Benefit category	*1996*	*1997*	*1997*	*1998*	*1999*
Undergraduate degree	0	79,399	128,261	184,975	207,660
MBA	1,979	1,979	4,946	7,914	10,882
Other postgraduate degree	2,473	7,419	8,409	9,893	10,882
Total	4,452	88,797	141,616	202,781	229,424
Present value in 1995	3,975	74,559	100,799	128,870	130,181
Cumulative PV (1996-2020)	3,072,392				

20. An alternative way of measuring the benefits is more useful for assessing the fiscal impact of the project. This methodology consists of calculating the benefits in a particular year and adding them to the cumulative benefits generated in previous years, and then discounting them to the year in which the assessment is being made. Thus, the benefits in the first year would be equal to the number of graduates times their incremental production. The benefits for the second year would be equal to the number of graduates times their incremental production *plus* the incremental production of the first-year graduates. Because the first methodology ascribes the present value of the benefits generated throughout the lives of the graduates to the year of graduation, it also ascribes the present value of the fiscal benefits to the year of graduation. However, the benefits are generated throughout the lives of the graduates. The second methodology, therefore, gives a more accurate time profile of the benefits. Table 11.5 presents calculations done with this methodology for the first five years of the project. The two methodologies should yield the same measure of benefits if the assumptions regarding life expectancy and employment rates are the same in both cases. However, unless the benefits are projected for 40 years after the project ends (to take into account the benefits generated by the last batch of graduates), it is extremely difficult to get the two methods to yield precisely the same answer if any shortcut is used. The differences are minor, however, and it is not worth spending the time to get the same answer.

Table 11.5: Gross Project Benefits, 1995-1999
(thousand 1995 Mauritius rupees)

Benefit category	*1996*	*1997*	*1997*	*1998*	*1999*
Undergraduate degree	0	9,631	25,190	47,629	72,818
MBA	240	480	1,080	2,040	3,360
Other postgraduate degree	300	1,200	2,220	3,420	4,740
Total	540	11,311	28,490	53,088	80,918
Cumulative PV (1996-2020)	3,148,598				

Estimates of Costs

21. Project costs were divided into six broad categories: (a) income forgone while students are in school; (b) capital costs, including costs of buildings and equipment; (c) training costs to upgrade existing faculty and train new faculty; (d) technical assistance, mainly salaries to pay replacement teachers while the regular faculty underwent training; (e) costs of additional personnel and salary increases paid to upgraded personnel; and (f) costs of maintaining additional equipment and buildings.

22. The second column of table 11.3 shows the amount of income forgone by students while in school. For all students, this amount is equal to what they would have earned had they remained employed rather than gone to school. These opportunity costs are gross of taxes and represent the value of the production lost to society while the students are in school. The total income forgone for Mauritius, then, would be equal to the number of students enrolled times their individual forgone income. Calculations through the year 2000 appear in table 11.6.

Table 11. 6. Forgone Income Calculation
(thousand 1995 Mauritius rupees)

Degree	*Present value in 1995 (1995-2020)*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Undergraduate		11,561	24,041	41,858	55,675	83,932	101,272
MBA/PhD		0	1,159	2,455	4,375	6,486	8,809
Total	1,181,132	11,561	26,100	47,013	63,200	94,018	114,131

23. Table 11.7 shows the five categories of investment costs. These are financial costs: they include import duties and have been converted from foreign into domestic currency using the market exchange rate. To calculate the economic costs, these amounts need to be adjusted in two ways: first, tradeables need to be priced at border prices, and second, border prices need to be converted to domestic prices using a shadow exchange rate, as discussed in chapter 5.

Table 11.7. Financial Investment Costs
(thousand 1995 Mauritius rupees)

Cost category	*1996*	*1997*	*1998*	*1999*	*2000*
Civil works	25,305	34,415	32,926	0	0
Equipment and furniture	77,641	5,331	3,281	6,480	0
Training, studies, and research	33,985	33,670	35,333	30,678	27,493
Consultants' services	4,664	3,605	23,074	29,155	0
Books	12,746	8,139	7,283	7,283	3,642
Total financial investment costs	154,340	85,161	101,897	73,595	31,134

24. The estimation of border prices in this case was simple because the only distortion stemmed from import duties. The border price, then, was equal to the financial cost minus the duty (table 11.8).

Table 11.8. Border Prices of Tradeables
(thousand 1995 Mauritius rupees)

	1996	*1997*	*1998*	*1999*	*2000*
Civil works					
Financial cost	25,305	34,415	32,926	0	0
Import duties	0	1,725	2,037	0	0
Border price	25,305	32,690	30,889	0	0
Equipment and furniture					
Financial cost	77,641	5,331	3,281	6,480	0
Import duties	11,475	781	481	950	0
Border price	66,166	4,550	2,800	5,530	0
Training, studies, and research					
Financial cost	33,985	33,670	35,333	30,678	27,493
Import duties	0	0	0	0	0
Border price	33,985	33,670	35,333	30,678	27,493
Consultants' services					
Financial cost	4,664	3,605	23,074	29,155	0
Import duties	0	0	0	0	0
Border price	4,664	3,605	23,074	29,155	0
Books					
Financial cost	12,746	8,139	7,283	7,283	3,642
Import duties	496	317	283	283	142
Border price	12,250	7,882	7,000	7,000	3,500

25. The final step was to estimate the economic cost of tradeables byadjusting for the foreign exchange premium. As explained in the appendix, the shadow exchange rate was estimated at 1.1 times the official exchange rate. This implies that from point of view of Mauritius, the economic border price of all tradeables is 10 percent higher than the financial border price.

26. For purposes of illustration, we will calculate one line from table 11.8 in detail and then show the totals, without going through each of the detailed calculations (table 11.9). In general terms, the procedure is to estimate the border price and then the economic price. The border price is calculated by deducting the import duty from the financial cost. The economic costs are calculated by adding the foreign exchange premium to the financial border price.[4]

4 We would have obtained the same result by applying the shadow exchange rate (SER) to the border price in dollars to obtain the border price in domestic currency, because the difference between the border price converted at the SER and the border price converted at the official exchange rate is the foreign exchange premium. The method for estimating the SER is described in Annex 11A.

Table 11.9. Economic Costs of Equipment and Furniture
(thousand 1995 Mauritius rupees)

Costs	*1996*	*1997*	*1998*	*1999*
Cost calculation				
Financial cost	77,641	5,331	3,281	6,480
– Import duties	11,475	781	481	950
= Border price	66,166	4,550	2,800	5,530
+ Foreign exchange premium	6,617	455	280	553
= Economic price	72,782	5,005	3,080	6,083
Conversion factor	0.9374	0.9388	0.9387	0.9387
Distribution of costs				
Financial cost to UM and polytechnics	77,641	5,331	3,281	6,480
Government income from import duties	-11,475	-781	-481	-950
Premium on foreign exchange	6,617	455	280	553
Economic cost to society	72,782	5,005	3,080	6,083

27. All of the relevant investment costs were calculated following the same methodology. The present value of the investment costs (discounted to 1995) was calculated at MR352 million. The results appear in table 11.10. These costs would be borne by the government through transfers to the UM. It should be noted that because not all the inputs are imported, the foreign exchange premium is not exactly equal to 10 percent of the border price.

Table 11.10. Economic Investment Costs
(thousand 1995 Mauritius rupees)

Total investment costs	*Present value 1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Financial costs for UM and polytechnics	342,659	154,340	85,161	101,897	73,595	31,134
Import duties	-15,796	-11,971	-2,823	-2,801	-1,233	-142
Foreign exchange premium	25,045	11,396	5,270	6,910	6,601	2,741
Economic costs	351,908	153,766	87,608	106,006	78,964	33,733

28. The final cost items are the incremental recurrent costs needed to keep the program in operation: the costs of additional personnel and salary increases paid to upgraded personnel, and costs of maintaining additional equipment and buildings. The present value of these costs as of 1995 was estimated at MR140 million. A summary of the present value of costs and benefits appears in column 4 of table 11.11. As the table shows, the project is likely to increase the country's welfare by about MR1.5 billion and therefore is acceptable from this point of view.

Table 11.11. Summary of Costs and Benefits, Net Present Value as of 1995
(thousand 1995 Mauritius rupees)

Costs and benefits	*Students (1)*	*UM and polys (2)*	*Government (3)*	*Society (4)*
Benefits				
Incremental income	2,204,019	0	944,579	3,148,598
Costs				
Forgone income	(910,119)	0	(271,014)	(1,181,133)
Tuition and fees	(258,781)	258,781	0	0
Investment costs	0	(342,659)	(9,900)	(352,559)
Incremental recurrent costs	0	(143,992)	0	(143,992)
Transfers from government	0	486,651	(486,651)	0
Total costs	(1,168,899)	258,781	(767,565)	(1,677,684)
Net benefits	1,035,119	258,781	177,015	1,470,915

Fiscal Impact Analysis

29. Column 3 of table 11.11 shows that the overall fiscal impact of the project is positive. The net benefits accruing to the government are on the order of MR177 million. This positive fiscal impact comes primarily from MR945 million in additional income taxes that the increased income of graduates generate. This income is counterbalanced by a loss of income taxes amounting to MR271 million while students are in school and do not work. The government also loses MR10 million from forgone import duties on reduced imports (the difference between the import duties generated by the project and the import duties that would have been generated by imports if the project had not been undertaken. This amount is given by the difference between the import duties generated by the project and the premium on foreign exchange). Finally, the institutional arrangement between the higher education complex and the government is for the latter to pay for all the costs of higher education, shown as transfers of MR487 million from the government to the educational complex.

A Public Sector or Private Sector Project?

30. Column 2 of table 11.11 shows the project from the point of view of the higher education complex. It is clear that the project would not be viable without government subsidy: the fees cover the recurrent costs, but not the investment costs. A private university, if it existed, would not be able to initiate this project without a subsidy from the government or from the private sector. If higher fees were charged, then fewer students would attend–the benefits of the project would be lower and the income of the higher education complex would depend on the elasticity of demand. In view of the many externalities associated with higher education (which are not assessed in monetary terms as benefits of the project), it would be questionable whether fewer students obtaining higher education would increase the net welfare of the country. The decision to leave the project to the private sector would then be a strategic one. The important point here is that the tools of economic analysis can shed light on the question, even if the final decision is more a matter of policy than economic analysis.

Risk Analysis

31. The present values shown in table 11.11 are calculated assuming that all the variables are certain. To assess risk and the *expected* NPV of the project, it is necessary to specify the variables that are considered random, their individual probability distributions, and any correlations among the variables. For purposes of this analysis it was assumed that enrollment rates, employment

rates after graduation, and the income differential between graduates and nongraduates were all uncertain (Annex 11B sets out the key assumptions behind the risk analysis). While costs are among the most important uncertain variables in most projects, in this case they were taken as certain because investment and recurrent costs are a minor proportion of potential benefits. Therefore, even if a major error in estimating costs had been made, the project's net benefits would still be positive and large. The project's NPV, however, is most sensitive to changes in the incremental productivity generated by the project, as measured by the income received by the students after graduation. This amount depends on three factors: enrollment rates, the income differential between graduates of the project and nongraduates, and the employment rate of graduates. If after graduation (a) the economic situation is such that unemployment among university graduates and MBAs is rampant, or (b) the differential in productivity (and hence income) between high school and university graduates (and between the latter and MBAs) is small, then the project's net benefits may turn negative. Also, if graduates emigrate, the benefits would materialize in a country other than Mauritius. Finally, if for some reason enrollment rates do not materialize as expected (the quality of the program is unsatisfactory, for example), the benefits of the project would not be forthcoming. To assess how these risks would affect the project's outcome, a Monte Carlo technique was used to estimate the expected NPV and its probability distribution.

32. Once we have chosen the variables that we will treat as random, the second step is to choose a probability distribution that best describes their behavior. Surveys and other empirical work undertaken as part of normal sector work can shed light on these issues; expert knowledge and experience can also be of help. In this case the appraisal team chose the probability distributions according to their own best judgment. For purposes of this Handbook, however, we chose different distributions to illustrate different aspects of the techniques. For the income differential variable, we chose a lognormal distribution. This distribution ranges from zero to infinity. Assuming that the income differential is lognormally distributed is equivalent to assuming that the income differentials between graduates and nongraduates could be infinitely large (with a virtually zero probability), but never negative: graduates would earn at least as much upon graduation as their less educated cohorts, but never less. This is obviously an empirical question that sector work would settle. From surveys we could have derived a frequency distribution of the income of high school graduates and of the income of university graduates and obtained the frequency distribution of the income differential. Lacking this information, we assumed a lognormal distribution. In particular, the income differential between high school and university graduates was assumed to be lognormally distributed with mean 108,000 and standard deviation of 13,300, and the income differential between university graduates and MBAs was assumed to be lognormally distributed with mean 120,000 and standard deviation of 12,000.

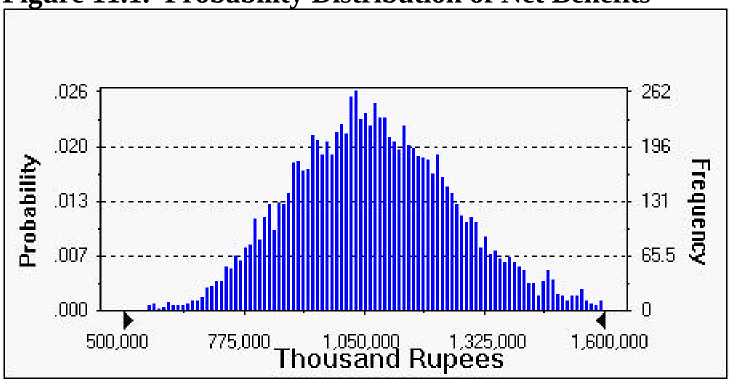
33. Similarly, sector work could have shed a light on the frequency distribution of employment rates. Lacking the information, we assumed that the employment rate obeyed a triangular distribution, with minimum value of 0.95, most likely value of 0.98, and maximum value of 100. This was equivalent to assuming that the employment rate for graduates would never fall below 95 percent and that most of the time it would be around 98 percent. It was also assumed that unemployment rates between two consecutive years were correlated and that unemployment rates and income differentials were contemporaneously correlated. If women represent a high percentage of the graduates and a significant proportion choose to remain at home, using the employment rates as proxies for the number of graduates entering the labor force would be wrong. In particular, the fiscal impact of the project would be less. The monetary benefits would also be less, but other, unmeasurable, benefits would not. Otherwise, women would enter the labor force.

34. The third critical factor was the enrollment rate, which was assumed to be distributed according to a different triangular distribution for each year and faculty. Analytically, varying

enrollment rates could have been approximated by lowering the lower bound of the employment rate. This, however, would have biased the results against the project as it would have been equivalent to assuming that the graduates would undergo all the costs of the project but enjoy none of the benefits. To avoid this bias and test the robustness of the project, a laborious process of specifying the distributions for each year and faculty was undertaken instead.

35. The analysis showed that the project was extremely robust to the risks considered. Even under the most adverse conditions (high unemployment and low income differential), the project's net benefits were assessed to be on the order of MR500 million. Figure 11.1 shows the assessed probability distribution of the incremental income accruing to society. The appraisal team assessed other risks, mainly concerned with costs. Their assessment was also that the project is extremely robust. Nevertheless, the analysis suggests that during supervision it would be advisable to follow closely the actual evolution of enrollment rates, employment rates, and income differentials.

Figure 11.1. Probability Distribution of Net Benefits



Sustainability

36. The higher education complex in Mauritius is for all practical purposes an extension of the central government. University professors are public employees, and the UM and the polytechnics receive direct funding from the government. Political pressures make these arrangements nearly sacrosanct. It is therefore unlikely that funding for the project would cease. Nevertheless, if these arrangements were to be modified in the future, how would the project fare?

37. A feature of the project that suggests that it is sustainable is the fact that the bulk of the costs are incurred early on in the project and last for only six years. The first six years therefore are the most difficult ones. The recurrent costs, of course, last indefinitely, but they are modest and are more than fully covered by tuition and fees. Nevertheless, it is another factor that should be kept in mind and followed closely during supervision: sustainability is more certain if student tuition and fees cover the full incremental costs.

38. Another aspect that suggests that the project is sustainable is the fact that its fiscal impact is highly positive. However, would the government perceive it as such? The outlays are clearly identified, but the income is not, as it comes from incremental income taxes. To help ensure government support it would behoove the educational complex to carry out a study demonstrating the project's positive fiscal impact. Absent such a study, the government might consider that the program is a net user of fiscal resources and might contemplate cutting funding if the fiscal situation were to tighten.

Cost Recovery

39. Charges levied on students via tuition and other fees more than cover incremental recurrent costs. Should the students pay for the recurrent costs? It is clear from table 11.13 that in the aggregate, students benefit handsomely from a university education, even if they are charged in full for incremental recurrent costs and contribute towards defraying investment costs. Of course, higher fees would mean fewer students, and a careful estimate of the elasticity of demand would be necessary if the university and the polytechnics considered charging higher fees. In addition, careful thought would have to be given to the structure of the fees, as more detailed analysis shows that not all graduates would obtain the same benefits. MBAs benefit the most, followed by bachelor's degree holders; however, the NPV of a PhD is negative.

Estimate of Benefits: Students' Viewpoint

40. To assess the relative benefits to students, we looked at the project from the point of view of a typical student. We chose three types of students—high school graduates, MBAs, and PhDs. For high school graduates, we chose a student from the engineering faculty. Engineering students take four years to graduate, and their income upon graduating is presumed to be the average income for university graduates. Other university programs take only three years. Therefore, if higher education is profitable for an engineering student, it is profitable for any student.

41. To calculate the benefits from the viewpoint of the students, we need to subtract income taxes from the expected salary after graduation and add tuition and fees to the costs. Income tax calculations presumed that the incremental income would be taxed at the applicable marginal rates and appear in table 11.12. This was a convenient assumption adopted for simplicity's sake. If a more detailed analysis had been useful, it would have necessary to collect information on deductions, nontaxable fringe benefits, and evasion. Gathering such information, however, would have been costly. While such information would have given a more precise idea of the distribution of benefits between students and government, it would not have altered the calculation of the net benefits to society. In this case the appraisal team was only interested in assessing the economic benefits, not in their precise distribution, and hence decided that the additional cost would not be worth incurring. Decisions such as this one must be made continuously throughout the appraisal process. In this sense, economic analysis is itself an exercise in cost-benefit analysis.

Table 11.12. Expected After-Tax Incremental Income
(1995 Mauritius rupees)

Level of education	*Expected salary*	*Income tax*	*After-tax income*	*After-tax incremental income*
MBA	300,000	82,250	217,750	84,000
Other postgraduate degree	240,000	64,250	175,750	42,000
Bachelor's degree	180,000	46,250	133,750	75,600
Secondary diploma	72,000	13,850	58,150	

42. From the point of view of a high school graduate, the benefits of a university education would be the present value of the expected after-tax incremental earnings. A typical high school graduate who goes on to obtain engineering degree would be able to increase his/her after-tax earnings from MR58,150 per year to MR133,750. The present value of the increased after-tax earnings (discounted at 12 percent for 40 years) would be MR623,000 upon graduation. Discounted back to the beginning of a program, this amount would be equivalent to MR396,000.

The present value of forgone earnings, tuition, and fees would be MR259,000. For a typical high school graduate, then, the present value of an engineering degree would be about MR137,000 (see table 11.13). Clearly, high school graduates would have an economic incentive to enroll in a engineering degree program.

Table 11.13. Net Present Value of an Engineering Degree
(1995 Mauritius rupees)

Costs and benefits	*Present value*	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Years 5-45*
Incremental income	396,074	0	0	0	0	623,230
Forgone income	197,816	58,150	58,150	58,150	58,150	
Tuition and fees	61,233	18,000	18,000	18,000	18,000	
Net benefits	137,024	(76,150)	(76,150)	(76,150)	(76,150)	623,230

43. MBA students would have an even greater incentive. Similar calculations show that for the typical student, the present value of an MBA would be MR253,000 (see table 11.14). The difference in the present value of an engineering degree and an MBA stems from two factors: shorter program (two instead of four years) and higher incremental income upon graduation.

Table 11.14. Net Present Value of an MBA
(1995 Mauritius rupees)

Costs and benefits	*Present value*	*Year 1*	*Year 2*	*Years 3-43*
Incremental income	552,039	0	0	692,477
Forgone income	253,170	133,750	133,750	
Tuition and fees	45,429	24,000	24,000	
Net benefits	253,440	(157,750)	(157,750)	692,477

44. A prospective PhD student, on the other hand, would have no economic incentive to enroll in a doctoral program: the net present value of a doctoral education is negative because after forgoing at least three years of income and paying tuition and fees, a PhD graduate would not earn more than a regular university graduate (see table 11.15). Anyone deciding to go for a PhD, then, would do so for noneconomic reasons.

Table 11.15. Net Present Value of a PhD
(1995 Mauritius rupees)

Costs and benefits	*Present value*	*Year 1*	*Year 2*	*Year 3*	*Years 4-44*
Incremental income	246,446				346,239
Forgone income	359,794	133,750	133,750	133,750	
Tuition and fees	64,561	24,000	24,000	24,000	
Net income	(177,910)	(157,750)	(157,750)	(157,750)	346,239

Conclusions

45. In summary, the project looks very robust. Its net benefits to society are considerable, and all of the main stakeholders gain from it: students increase their earnings potential, the government stands to collect more taxes because of the project, and the educational complex stands to gain in size and prestige. The project has several risks. Endogenous risks are that the government may fail to introduce the policy changes needed to improve higher education, as it stated in its policy letter, and that the higher education institutions may fail to improve the quality of the education being provided. This latter failure would reduce demand for the services of the higher education institutions. To address this risk, the project incorporates appropriate measures to ensure that the quality of the education would be up to international standards: provisions for twinning with reputable international universities, accreditation visits, and development of postgraduate and research programs. The major exogenous risk was poor macroeconomic performance leading to lower demand for university graduates and to lower employment rates and lower income differentials. These risks were taken into account and simulated through Monte Carlo techniques: even under the most adverse circumstances, combining high unemployment rates, low enrollment rates, and low income differentials, the project's net benefits remained positive.

Annex 11A. Estimation of the Shadow Exchange Rate (SER)

46. Mauritius is an open economy with few trade distortions; hence the market rate for foreign exchange closely reflects the opportunity cost to the country of using foreign exchange. Nevertheless, the import and export duties that Mauritius imposes distort the foreign exchange market, driving a wedge between private and social costs. The appraisal team did not calculate an SER because it estimated that the premium on foreign exchange was small and, even if large, would not alter the analysis because the cost of the imported components were not critical to the outcome of the project. The SER was estimated in this exercise to illustrate the use of the technique.

47. The calculation of the shadow exchange rate was done using the methodology explained in the Technical Appendix. First, using IMF data (IFS and GFS), the average import duty rate levied by Mauritius for all goods for the years 1990-1994 was calculated. Second, the average export duty for the same time period was calculated. Third, the effective exchange rate for imports was calculated by augmenting the official exchange rate by the import duty rate. Similarly, the effective exchange rate for exports was calculated by subtracting the duties from the exchange rate. The final step was to obtain a weighted average of the effective exchange rates for exports and imports, using the methodology discussed in the Technical Appendix. Table 11A.1 shows the detailed calculations.

48. For this case, we assumed that the supply of exports in Mauritius was more responsive than the demand for imports to changes in the value of the real exchange rate, we used -1.00 for the elasticity of imports and 1.25 for the export elasticity. These assumptions are consistent with what we know about Mauritius' economy: its exports compete in highly contested markets and thus small price movements in the real exchange rate are likely to make Mauritius noticeably more or less competitive and hence to affect its exports. Since Mauritius is a small island that imports most of its basic necessities and raw materials, the volume of its imports is likely to be less affected by exchange rate movements. Of course, more information gathered in the context of ESW would have helped refine these judgments. The foreign exchange premium, estimated with the information available, ranged from 7.3 percent in 1990 to 8.4 percent in 1994.

49. Table 11A.1 also shows another estimate of the SER using a more disaggregated breakdown of imports and import duties provided by the government for 1992. According to this estimate, the foreign exchange premium in 1992 was 15.5 percent—still moderate, but high enough to make a substantial difference in projects with a large import component. If there is a wide dispersion of duty rates, disaggregated data are likely to yield more precise estimates of the SER and foreign exchange premium.

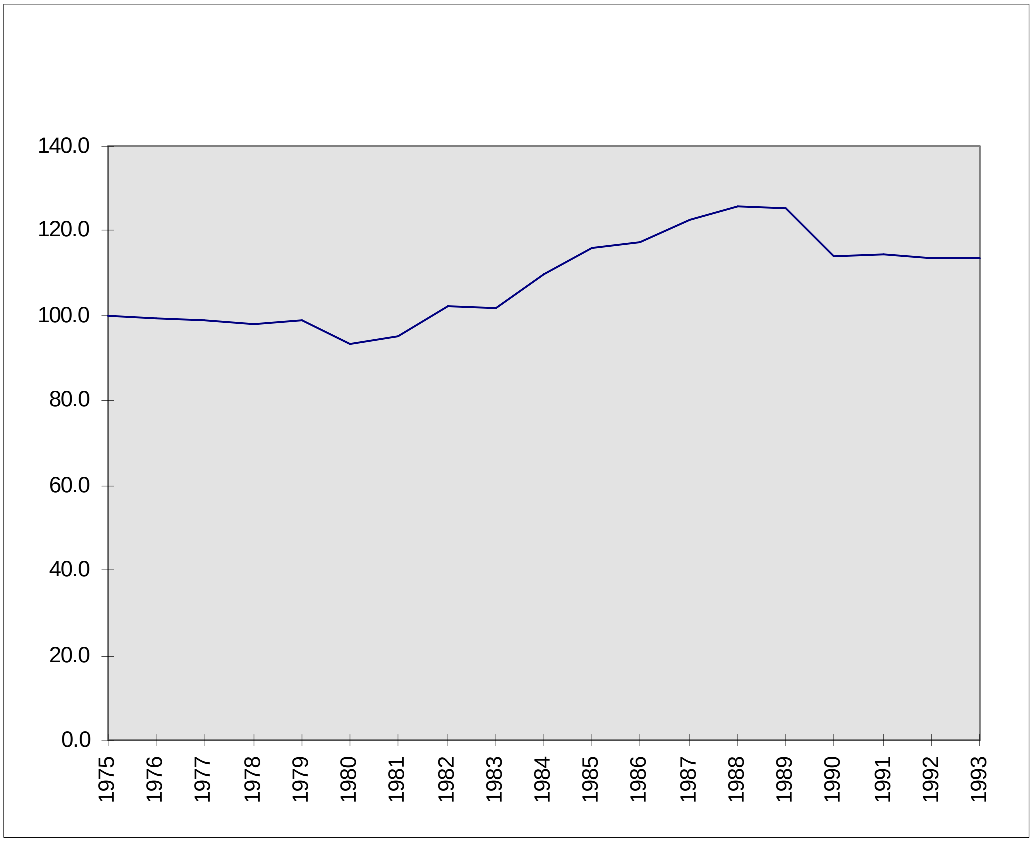
50. In short, a lower bound for the SER would be 1.08 times the market rate, and an upper bound would be 1.15 times the market rate. For purposes of this exposition, we used a 10 percent premium for foreign exchange.

Table 11A.1. Estimate of the Shadow Exchange Rate

Category	*1990*	*1991*	*1992*	*1993*	*1994*
Market exchange rate (MR/$)	14.32	14.79	17.00	18.66	17.86
Exports, FOB (thousand MR)	17,677	18,700	20,244	22,992	21,414
Imports, CIF (thousand MR)	21,921	22,212	22,931	27,507	29,307
Import duties collected (tho. MR)	3,703	4,247	4,159	4,685	5,200
Export duties collected (tho. MR)	374	427	416	433	400
Import duties as % of imports	16.89	19.12	18.14	17.03	17.74
Export duties as % of exports	2.12	2.29	2.06	1.89	1.87
Effective exchange rates					
For exports (Px)	14.02	14.46	16.65	18.30	17.53
For imports (Pm)	16.74	17.62	20.08	21.83	21.03
Elasticity of supply of exports	1.25				
Elasticity of demand for imports	-1.00				
Weights					
For Px (Wx)	0.50	0.51	0.52	0.51	0.48
For Pm (Wm)	0.50	0.49	0.48	0.49	0.52
Estimate of SER	15.37	16.00	18.28	20.03	19.36
Premium on foreign exchange (%)	7.3	8.1	7.5	7.3	8.4
		Alternative Estimate of SER			
Effective exchange rates					
For imports of consumer goods			19.02		
For imports of intermediate goods			19.77		
For imports of capital goods			21.32		
		Elasticities	Weights		
For consumer goods		-1.00	0.11		
For intermediate goods		-1.25	0.32		
For capital goods		-0.75	0.10		
SER for 1992			19.63		

51. As the Handbook's Technical Appendix discusses, a more important question is the likely path for the real exchange rate. Is the exchange rate undervalued or overvalued? What is likely to happen in the future? A plot of the real exchange rate suggested that it underwent a depreciation of about 20 percent during the 1980s and a sharp appreciation in 1990, and that it has remained steady since then (see figure 11A.1). We also noted that the deficit in the current account of the balance of payments has been less than 1 percent of GDP. From these two factors, the judgment was made that the real exchange rate was likely to remain constant at least through 2,000, the last year in which the project uses tradeables.

Figure 11A.1. Mauritius: Real Exchange Rate, 1975-1993



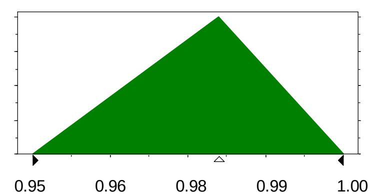
Annex 11B. Key Assumptions

Table 11B.1. Transition Rates for Degree Courses by Faculty
(percentage)

	Y1/Y2	*Y2/Y3*	*Y3/Y4*	*Grad.*	*Overall*
Agriculture	95	98		97	90
Engineering	90	98	98	98	85
Law and management.	80	95		95	72
Science	73	98		98	70
Soc. sci. and hum.	73	98		98	70
MBA	100	100			100
Postgraduate	100	100	100		100

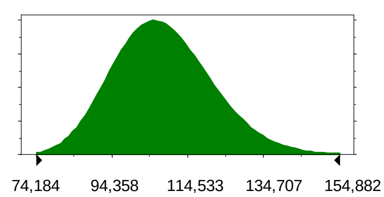
Employment Rates

52. Employment rates were assumed to be uncertain and distributed according to a triangular distribution with minimum value equal to 95 percent, likeliest value equal to 98 percent, and maximum value equal to 100 percent.



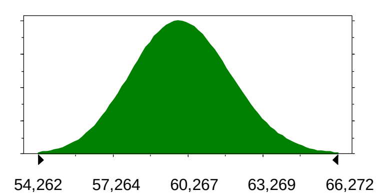
Incremental Income for University Graduates

53. Incremental income for university graduates was assumed to be uncertain and distributed according to a lognormal distributions, with mean 108,000 and standard deviation equal to 13,300. The mean value in the simulation was 107,917.



Incremental Income for PhDs

54. Incremental income for graduates of doctoral programs was assumed to be uncertain and distributed according to a lognormal distribution with mean 60,000 and standard deviation equal to 2,000. The mean value in the simulation was 60,037.



Incremental Income for MBAs

55. Incremental income for MBAs was assumed to be uncertain and lognormally distributed with mean 120,000 and standard deviation of 12,000. The mean value in simulation was 120,100.

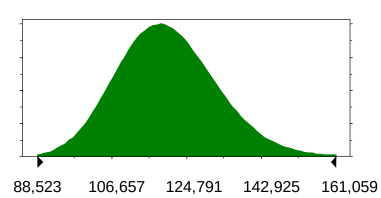


Table 11B.2. Expected Increase in Enrollment

Level	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009-2020*
Undergraduates	161	334	581	773	1,166	1,407	1,641	1,879	2,183	2,485	2,785	3,084	3,298	3,396	3,417
MBAs		6	14	24	36	49	63	79	96	115	136	158	184	211	242
MAs/PhDs		5	15	18	20	23	28	30	32	34	36	38	40	42	44

Table 11B.3. Flows of Benefits and Costs from Different Points of View

Thousand 1995 Mauritius Rupees

	PV	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010-2020
Society's Viewpoint																	
Additional graduates (number)	3,586	0	7	108	169	240	271	446	485	506	643	721	790	909	992	1,023	5780
Incremental income	3,148,598	0	540	11,311	28,490	53,088	80,918	127,097	177,324	229,737	296,630	371,758	454,182	549,208	653,027	760,148	10,938,261
Forgone income	1,181,132	11,561	26,100	47,013	63,200	94,018	114,131	134,474	154,880	180,207	205,720	231,436	257,377	277,693	290,075	297,420	1,680,489
Investment costs	352,559	0	154,495	87,608	106,006	78,964	33,733	0	0	0	0	0	0	0	0	0	
Recurrent costs	143,992	3,900	10,444	14,408	15,147	18,266	20,465	21,424	21,470	20,921	20,894	20,894	20,894	20,894	20,894	20,894	118,056
Net benefits	1,470,915	-15,461	-190,499	-137,718	-155,863	-138,159	-87,411	-28,801	973	28,609	70,017	119,428	175,911	250,621	342,057	441,834	9,139,716
Student's Viewpoint																	
Incremental income	3,148,598	0	540	11,311	28,490	53,088	80,918	127,097	177,324	229,737	296,630	371,758	454,182	549,208	653,027	760,148	10,938,261
Incremental income taxes	944,579	0	162	3,393	8,547	15,926	24,275	38,129	53,197	68,921	88,989	111,527	136,255	164,762	195,908	228,044	3,281,478
After-tax incremental income	2,204,019	0	378	7,918	19,943	37,162	56,643	88,968	124,126	160,816	207,641	260,231	317,927	384,446	457,119	532,104	7,656,782
Forgone income	1,181,132	11,561	26,100	47,013	63,200	94,018	114,131	134,474	154,880	180,207	205,720	231,436	257,377	277,693	290,075	297,420	1,680,489
Forgone income taxes	271,014	2,224	5,451	10,007	13,767	20,403	25,048	29,841	34,699	40,588	46,612	52,785	59,121	64,508	68,514	71,711	405,182
After-tax forgone income	910,119	9,337	20,648	37,006	49,433	73,614	89,083	104,633	120,181	139,619	159,107	178,651	198,255	213,185	221,562	225,709	1,275,306
Tuition and fees	258,781	2,890	6,130	10,824	14,339	21,463	25,858	30,200	34,547	40,063	45,549	51,001	56,416	60,321	62,130	62,555	353,451
Net benefits	1,035,119	-12,228	-26,401	-39,912	-43,828	-57,916	-58,299	-45,865	-30,601	-18,866	2,985	30,579	63,256	110,940	173,427	243,839	6,028,025
Government's Viewpoint																	
Incremental income taxes	944,579	0	162	3,393	8,547	15,926	24,275	38,129	53,197	68,921	88,989	111,527	136,255	164,762	195,908	228,044	3,281,478
Forgone income taxes	271,014	2,224	5,451	10,007	13,767	20,403	25,048	29,841	34,699	40,588	46,612	52,785	59,121	64,508	68,514	71,711	405,182
Additional import duties	15,796		11,971	2,823	2,801	1,233	142	0									
Minus forex premium	25,697		12,126	5,270	6,910	6,601	2,741										
Transfers to UoM & Polys	486,651	3,900	164,784	99,569	117,044	91,861	51,599	21,424	21,470	20,921	20,894	20,894	20,894	20,894	20,894	20,894	118,056
Net fiscal impact	177,015	-6,124	-170,229	-108,630	-126,373	-101,706	-54,971	-13,136	-2,972	7,412	21,483	37,848	56,239	79,361	106,500	135,440	2,758,240
Educational Complex's Viewpoint																	
Tuition and fees	258,781	2,890	6,130	10,824	14,339	21,463	25,858	30,200	34,547	40,063	45,549	51,001	56,416	60,321	62,130	62,555	353,451
Transfers from government	486,651	3,900	164,784	99,569	117,044	91,861	51,599	21,424	21,470	20,921	20,894	20,894	20,894	20,894	20,894	20,894	118,056
Investment costs	342,659	0	154,340	85,161	101,897	73,595	31,134	0	0	0	0	0	0	0	0	0	0
Recurrent costs	143,992	3,900	10,444	14,408	15,147	18,266	20,465	21,424	21,470	20,921	20,894	20,894	20,894	20,894	20,894	20,894	118,056
Net benefits	258,781	2,890	6,130	10,824	14,339	21,463	25,858	30,200	34,547	40,063	45,549	51,001	56,416	60,321	62,130	62,555	353,451

Technical Appendix

1. This technical appendix presents basic concepts concerning discounting techniques as well as the conceptual framework for estimating the main adjustments to market prices needed to reflect social opportunity costs and benefits in project evaluation.

Discounting and Compounding Techniques

2. The decision on a project's acceptability hinges on whether the benefits exceed the costs. If all benefits and costs occurred in the same year, the decision would be a simple one of comparing benefits and costs. Usually, however, benefits and costs occur at different times, with many costs preceding benefits and, during the first years of the project, usually exceeding them. This issue arises in both economic and financial analysis. The techniques used to compare costs and benefits that occur in different years are the same in both types of analysis. These techniques are called "discounting techniques."

3. Discounting is essentially a technique that enables us to compare the value of dollars in different time periods. A dollar received today is worth more than a dollar received tomorrow because the dollar received today enables us to increase our consumption today, whereas the dollar received in the future can increase only future consumption. The fact that we have to postpone consumption makes tomorrow's dollar less valuable than today's, even if tomorrow's dollar has as much purchasing power as today's dollar. The declining value of money over time has nothing to do with inflation, only with the postponement of consumption.

4. The declining value of money over time explains in large measure why we require interest whenever we lend money. Lending money out entails postponing consumption. To compensate for postponing of consumption, we demand for every dollar we lend an amount that enables us to increase our consumption in the future. Thus, whenever we open a savings account and place our money at, say, 5 percent interest per year, we are implicitly stating that for us $1.05 one year from today is worth at least as much as $1.00 today. If we buy a five-year certificate of deposit that pays 5 percent per year, for every dollar we give up today, we will receive $1.28 in five years (assuming that interest is compounded annually): we are implicitly stating that $1.28 five years hence is worth at least as much as $1.00 today.

5. Discounting involves the reverse procedure; it answers the question, how much is $1.28, received in five years, worth today? The answer depends on the interest rate we are willing to accept. If we are willing to accept an interest rate of 5 percent per year, then $1.28 in five years is worth $1.00 today. Equivalently, we are saying that $0.78 today is worth $1.00 in the future ($1.00/$1.28 = $0.78).

The Mechanics of Discounting and Compounding

6. The mechanics of discounting are very simple, and routines for discounting are now part of any spreadsheet program (Lotus 1-2-3, Excel, Quattro Pro). For the sake of illustration, we present here an example on compounding. Suppose that we place $100 at 10 percent per year for five years in a savings account where interest is paid on the total amount in the account at the end of the year. Table TA.1 shows the account balances for the five years:

Table TA.1. Interest Accumulation

Year	*Amount at beginning of year*	*Interest earned during the year*	*Compounding factor*	*Amount at end of year*
1	100.00	10.00	1.10	110.00
2	110.00	11.00	1.10	121.00
3	121.00	12.10	1.10	133.10
4	133.10	13.31	1.10	146.41
5	146.41	14.64	1.10	161.05

7. In this example, we calculated the ending balance by calculating the interest due at the end of the year and adding it to the amount outstanding at the beginning of the year. We could also have calculated the year-end balance by multiplying the previous year's ending balance by the compounding factor (1 + *i*), where *i* stands for the interest rate. Both methods lead to the same result. The above relations can be expressed in algebraic terms. If the interest rate is *i*, then

$$\textit{Future value of one dollar in year } t = (1+i)^t$$

8. Discounting would reverse the procedure. Beginning with the ending balance, we would ask, What would be the value of $161.05 received five years from today if we are willing to receive 10 percent per year? To obtain the answer, we would *divide* the balance outstanding at the end of the last year by 1.10: $161.05 ÷ (1.10) = 146.41. We would repeat the procedure until we reach the present. The value of future flows discounted to the present is called, not surprisingly, the *present* value. The interest rate that we use to discount the flows is called the *discount* rate. As before, the relation can also be expressed in algebraic terms. At interest rate *i*,

$$\textit{Value today of a dollar received in year } t = 1 \div (1+i)^t$$

Net Present Value Criterion

9. The present value of the net benefits of a project is the basic economic criterion that the Bank uses for accepting or rejecting a project. Two conditions must be satisfied if a project is to be acceptable on economic grounds: (a) the expected present value of the net benefits (or net present value [NPV]) of the project must not be negative when discounted at an appropriate rate; and (b) the project's expected NPV must be at least as high as the NPV of mutually exclusive alternatives.[1]

Internal Rate of Return

10. Although the NPV is the criterion the Bank uses to evaluate projects, many Bank staff use the internal rate of return (IRR), called the ERR to signal that the analysis is in economic rather than in financial terms. The IRR is the discount rate that results in a zero NPV for the project. It is also the yield to maturity of a bond. If the IRR equals or exceeds the appropriate discount rate, then the project's NPV will be not be negative and the project will be acceptable from the NPV point of view as well. For example, in the Viet Nam Highway Rehabilitation project discussed in

1 For investments where no consensus exists on how to value benefits in monetary terms, it is necessary to specify alternative project success criteria, and yardsticks for monitoring progress during implementation and measuring success on completion. Such projects must normally be shown to represent the expected least-cost condition for achieving the posited expected benefits.

Box 3.1, the discounted net benefits of the project (NPV) amounted to $532.56 million and the IRR was 77.2 percent (see table TA.2).

Table TA.2. Viet Nam Highway Rehabilitation Project: Calculation of NPV
(US $ millions)

Year	*Net benefits*	*Discount factor*	*Discounted net benefits*
1994	-30.9	1.00	-30.9
1995	-14.1	1.10	-12.8
1996	28.3	1.21	23.4
1997	53.4	1.33	40.1
1998	66.0	1.46	45.1
1999	80.6	1.61	50.1
2000	98.4	1.77	55.5
2001	118.6	1.95	60.8
2002	144.1	2.14	67.2
2003	173.3	2.36	73.5
2004	203.3	2.59	78.4
2005	234.4	2.85	82.2
NPV:			532.6

11. In most cases, both techniques lead to the same result: a project whose NPV is greater than or equal to zero at some discount rate, say *d*, also has an IRR that is greater than or equal to *d*: we will accept or reject the project regardless of the criterion we use. There are many difficulties with the IRR criterion, however, and it should be avoided for making decisions, especially when comparing mutually exclusive alternatives. First, not every project has an IRR. If, for example, the net benefits of the project begin so soon that the project shows positive net benefits in every year, then the IRR does not exist.[2] Second, some projects may have more than one IRR; in these cases, the IRR rule breaks down. Multiple IRRs arise when the project's net benefits change sign more than once during the life of the project. For example, a project that has negative net benefits during the first two years, positive net benefits during the next two years, negative net benefits again the fifth year (perhaps because of new investments), and positive net benefits thereafter can have up to three IRRs. In general there can be as many IRRs as there are sign changes in the stream of net benefits.

12. To be sure, most projects begin with negative net benefits that turn positive and remain positive until the end of the project. For these projects, the IRR and NPV are equivalent in the sense that projects acceptable under one criterion are also acceptable under the other, and projects that are unacceptable under one criterion are also unacceptable under the other. Thus, if the NPV is positive when the flows are discounted at some rate, *r*, the IRR is greater than *r*. Likewise, projects with negative NPV (with benefits discounted at *r*) have an IRR lower than *r*. Moreover, the same information is needed to use either criterion: in both cases we need to calculate the

[2] Of course, the time periods can be redefined in a way that avoids this poblem. For example, if the project's cash flows may be defined in terms of months, a monthly IRR may be calculated.

project's net benefits. If we calculate the NPV, we need to choose a rate to discount the benefits to the present. If we use the IRR, we need to choose a rate to decide whether the IRR is acceptable.

Comparison of Mutually Exclusive Alternatives

13. So far, we have talked about the equivalence of the two rules in reference to a single project. When projects are independent, as long as the NPV is not negative, the project is acceptable. The fact that one project may have a higher IRR, though lower NPV, than another project is irrelevant. However, when choosing among projects or project designs that are mutually exclusive—in the sense that they are alternative ways of producing exactly the same output (e.g., hydro vs. thermal power production)—differences in ranking are important.

14. To illustrate these concepts, consider a small and a large irrigation scheme for the same site. If the small scheme is built, it will preempt use of the site for the large one; hence they are mutually exclusive. The NPV, IRR, and total cost of each design appear in table TA.3. If we use the IRR to select between the two options, we would opt for the small-scale irrigation alternative. If we use the NPV to select between alternatives, we would choose the larger project. Which one is "correct"? Because the NPV criterion maximizes the net benefits accruing to the country, it is preferable. If we choose the smaller project, the country will forgo 241.9 million in net benefits.

Table TA.3. Comparison of Alternatives Using NPV and IRR

Alternative	*NPV (millions of units domestic currency)*	*IRR*	*Cost (millions of units domestic currency)*
Small-scale irrigation	441.2	27%	500
Large-scale irrigation	683.1	16%	2,500

Note: Adapted from Gittinger (1982b), tables 10–7 and 10–8.

15. Why does the IRR lead to the "wrong" decision? The answer concerns the initial capital outlays and the incremental benefits that they entail. The large irrigation project requires five times as large an investment as the small irrigation project. The additional investment (2 billion) has declining marginal productivity and hence does not increase the benefits of the project by a commensurate amount; that is, it has a lower rate of return than the initial outlays. Nevertheless, the lower rate of return of the *incremental* amounts is still acceptable, and hence the bigger project's NPV is higher, but not five times as high. The IRR is unable to yield this information and should not be used to decide among mutually exclusive projects. As long as the incremental amounts have a lower rate of return (and hence the larger alternative or project has a lower IRR), the IRR will be biased against the larger alternatives/projects.[3]

16. The loss of information entailed in the IRR criterion can be avoided if, in addition to calculating the IRR on the "base" alternative (the small irrigation project, in this case), we calculate the IRR on the incremental funds needed to go from the small to the large irrigation scheme. In the specific example illustrated in table TA.3, the incremental funds had an IRR of 14

[3] It is a common misconception to think that the larger the project, the larger the NPV. This correspondence does not always hold.

percent, which, though lower, was still above the chosen cut-off rate of 12 percent.[4] From this point of view, as well, the larger project was preferable.

17. As another example, table TA.4 illustrates a hypothetical project with four technically feasible alternative designs.

Table TA.4. Assessment of Alternative Designs

	Benefits per project year								
Design	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*NPV*	*IRR*
A	-12,000	3,500	3,500	3,500	3,500	3,500	3,500	1,268	14.1
B	-20,000	6,000	6,000	6,000	6,000	6,000	6,000	2,744	15.2
C	-28,000	8,000	8,000	8,000	8,000	8,000	8,000	2,326	13.2
D	-32,000	8,800	8,800	8,800	8,800	8,800	8,800	1,358	11.6

At a 10-percent discount rate, all of these designs are acceptable. Design B is optimal because it has the highest NPV. If we had explored only design D, we would have accepted it, but we would chosen the worst design from the economic point of view.

18. When examining alternative designs such as these, it is useful to calculate the marginal returns to each design, either by calculating the marginal NPV (MNPV) or the marginal IRR (MIRR). In the example above, design B has a high return—for an additional investment of 8,000 it increases annual benefits by 2,500. As a result, the present value of the design is more than double that of design A. Design C, on the other hand, has an additional cost of 8,000, but annual incremental benefits of only 2,000—its MNPV is negative, as shown in table TA.5. This example illustrates a useful rule: When considering several designs each of which involves incremental investments, choose the design with the highest NPV, or else invest up to the point where the MNPV becomes zero (MIRR is just equal to the discount rate):

Table TA.5. Assessment of MNPV and MIRR

	Benefits per project year								
Design	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*MNPV*	*MIRR*
A	-12,000	3,500	3,500	3,500	3,500	3,500	3,500	1,268	14.1
B-A	-8,000	2,500	2,500	2,500	2,500	2,500	2,500	1,477	17.0
C-B	-8,000	2,000	2,000	2,000	2,000	2,000	2,000	-418	7.9
D-C	-4,000	800	800	800	800	800	800	-967	0.0

If we had chosen design D, we would have spent 4,000 units over and above the cost of design C for nothing: the present value of the project would have been lower because the additional benefits would not have compensated for the additional investment. As the last column shows, the IRR on the additional investment would have been exactly zero.

4 The detailed calculations appear in Gittinger, *op. cit.*, p. 379

19. Because the IRR is expressed in percentage terms, it does not depend on any unit of measurement and seemingly facilitates comparisons among projects, even across countries and years. A project with an IRR of 25 percent seems like a better project than one with an IRR of only 10 percent, wherever the two projects are to be undertaken.[5] Also, because of its close resemblance to the rate-of-profit notion, the IRR appeals to decision makers; it has long been standard practice at the Bank to select projects and present the results of economic analysis using the IRR. However, when evaluating projects, and especially when selecting alternative designs, analysts should be aware of the limitations of the IRR and use the NPV criterion. The IRR is a useful summary statistic to present the results of analysis, but it is not a good basis for making decisions.

The Discount Rate

20. It is evident from this discussion that the rate used to discount net benefits or used as a cut-off point is crucial. The discount rate used should reflect not only the likely returns of funds in their best relevant alternative use (i.e., the opportunity cost of capital or "investment rate of interest"), but also the marginal rate at which savers are willing to save in the country (i.e., the rate at which the value of consumption falls over time, or "consumption rate of interest"). The Bank traditionally has not calculated a discount rate but has used 10-12 percent as a notional figure for evaluating Bank-financed projects. This notional figure is not necessarily the opportunity cost of capital in borrower countries, but is more properly viewed as a rationing device for World Bank funds. Task managers may use a different discount rate, as long as departures from the 10-12 percent rate have been justified in the Country Assistance Strategy. (For guidance on how to calculate the discount rate, see paras. 2–8 of this Technical Appendix).

Conceptual Framework

21. This conceptual framework is based on three basic postulates:

(a) Competitive demand price measures the benefit of each marginal unit to the demander.

(b) Competitive supply price (or marginal cost) measures the opportunity cost of each marginal unit from the standpoint of the suppliers.

(c) In attempting to measure the benefits and costs to a society as a whole, one must take the difference between benefits and costs.

22. The framework uses the same basic approach for the valuation of all goods and services, be they material inputs, foreign exchange, or capital. The approach presumes that the government purchases goods or services for use in its own projects in a relatively well-functioning, though

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5 This notion is a misconception. Project A is not necessarily better than Project B because its IRR is higher. Suppose that we have two projects with the following cash flows:

A	-1	1	2
B	-2	1	4

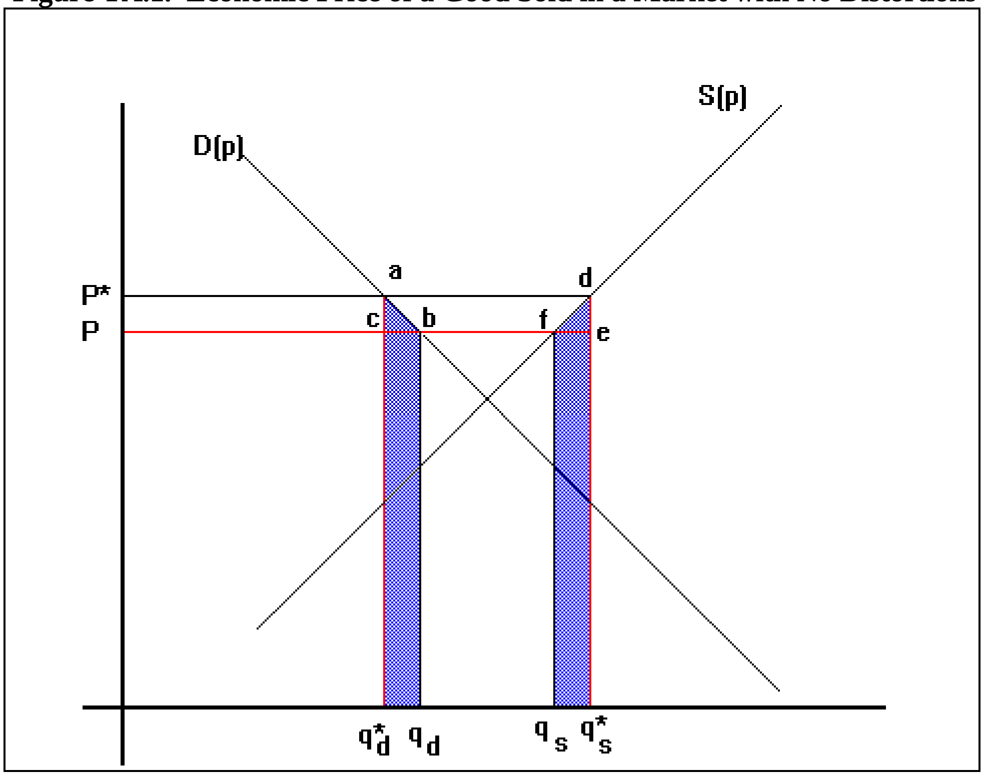
Project A has an IRR of 100 percent while project B has an IRR of 68 percent. The present value of B is higher than the present value of A at any discount rate lower than 68 percent. Is project A better than project B? As long as we can borrow and lend at less than 68 percent, by appropriate inter-period borrowing and lending we can make the cash flows of B at least as good as those of A in each period. For example, if the discount rate is 10 percent, we can borrow $1.21 from period 3 and lend it to period 1 to obtain the following cash flow:

-1 1 -2.79

($1.21 discounted at 10 percent for two periods is equal to $1). We have thus reproduced the cash flows of project A and still have $0.79 left over in period 3. We could not have performed similar transactions for project A. In this sense, B is better than A. For any discount rate greater than 68 percent, A is better than B.

distorted, market and that in doing so it bids up the price of the good in question. The additional government demand is satisfied either through (a) reduction of consumption of the good on the part of existing consumers, (b) increased production of the good on the part of existing producers, or (c) a combination of both. The basic principle used for valuing the good or service is that the value to society of the goods or services diverted to the project is the sum of the values placed by consumers on the forgone consumption, plus the cost of increasing production. Although for expository purposes the approach presumes that there is full capacity utilization, the principles can be applied equally well if there are unemployed resources.

Figure TA.1. Economic Price of a Good Sold in a Market with No Distortions



23. To illustrate this basic principle, we first consider the valuation of any material input, say cement, in a distortion-free and autarkic environment. The market price of cement in this case is determined solely by domestic supply and demand, and there is a single market price for consumers and producers (see figure TA.1).

24. At the market price, P, for cement, the private sector produces q_s and consumes q_d. The government, whose demand curve is not shown in the diagram, consumes the quantity bf or q_s-q_d. When the government decides to implement new projects, its demand curve is displaced to the right. If there are no imports, the additional government demand must be satisfied either from a reduction in consumption, an increase in production, or a combination of both. In response to the government's new demand, the price of cement goes up by some minute amount, which for purposes of illustration, is shown here as a discrete and perceptible amount. Assume that the government bids the price up to P*. At the new price, consumers reduce their purchases from q_d to q_d^* and producers increase their production to from q_s to q_s^*. In this case, the government satisfies

its additional demand from the reduced consumption $q_d - q_d^*$ and from additional production, $q_s^* - q_d$: the new projects consume the difference between bf and ad. The basic valuation principle used in this Handbook is that the value to society of the goods diverted to the project is given by the value placed by consumers on their reduced consumption and the cost of increasing production, i.e., by the sum of the shaded areas under the demand and supply curves.

25. The value placed by consumers on the cement transferred to the project is equal to $P\Delta D + 1/2\Delta P\Delta D$, where $\Delta P = (P^* - P)$ and $\Delta D = (q_d - q_d^*)$. This amount may be divided into two parts:

- the market value of the units transferred to the project ($P\Delta D$), plus
- the loss in consumer surplus ($1/2\Delta P\Delta D$).

Likewise, if we let $\Delta S = (q_s^* - q_s)$, the cost of producing the cement transferred to the project is $P\Delta S + 1/2\Delta P\Delta S$.

26. The total value of the cement transferred to the project, then, is

$$P\Delta D + 1/2\Delta P\Delta D + P\Delta S + 1/2\Delta P\Delta S,$$

and the *unit* cost of the cement transferred to the project is equal to the total cost divided by the number of units transferred:

$$\frac{P\Delta D + 1/2\Delta P\Delta D + P\Delta S + 1/2\Delta P\Delta S}{\Delta D + \Delta S} \qquad (1)$$

For very small changes in demand (which is normally the case for most projects), the changes in consumer and producer surplus (i.e., the term $1/2\Delta P\Delta D + 1/2\Delta P\Delta S$) are negligible, and equation (1) reduces to:

$$\frac{P\Delta D + P\Delta S}{\Delta D + \Delta S} \qquad (2)$$

27. The areas under the demand and the supply curve will depend on the respective elasticities of supply and demand. This can be appreciated by expressing ΔD and ΔS as follows:

$$\Delta D = q_s \left(\frac{P\Delta D}{q_s \Delta P} \right) \frac{\Delta P}{P} = \eta q_s \frac{\Delta P}{P} \qquad (3)$$

$$\Delta S = q_s \left(\frac{P\Delta S}{q_s \Delta P} \right) \frac{\Delta P}{P} = \varepsilon q_s \frac{\Delta P}{P} \qquad (4)$$

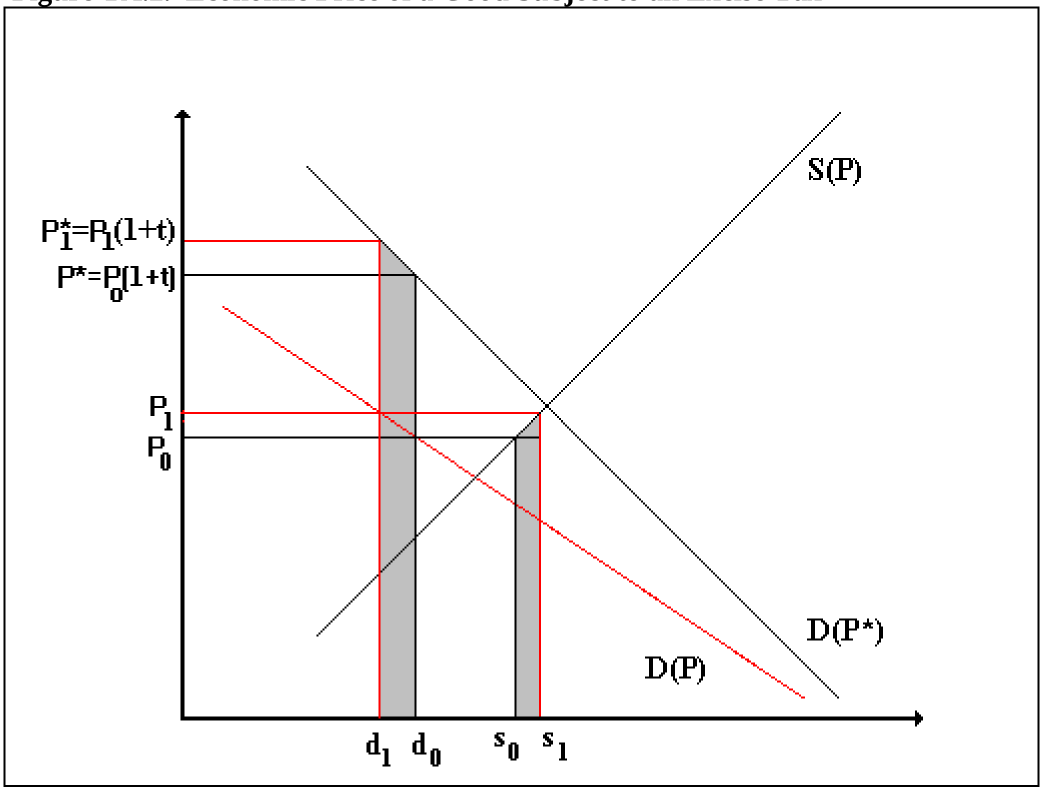
If we substitute these expressions into (2), we obtain:

$$P\left(\frac{\eta q_d}{\eta q_d + \varepsilon q_s} \right) + P\left(\frac{\varepsilon q_s}{\eta q_d + \varepsilon q_s} \right) \qquad (5)$$

where η is the elasticity of demand with respect to its own price and ε elasticity of supply with respect to its own price. Equation (5) simply says that the unit value that society places on the units diverted to the project is equal to the market price of the good. This is exactly what we would expect in the simple case where there are no distortions.

28. The effect of introducing a distortion in the market is to drive a wedge between the social and the private cost of consuming or producing the good. For purposes of illustration, we introduce a distortion in the form of an excise tax levied as a percentage of the price of the good (see table TA.2). Although this particular distortion is in the form of a tax, the conceptual approach would be the same regardless of the nature of the distortion.

Figure TA.2. Economic Price of a Good Subject to an Excise Tax



29. The effect of the excise tax can be depicted as a displacement of the demand curve to the left, with the vertical distance between the two curves measuring the value of the tax. As before, at the initial equilibrium the market price is P_0. The government purchases s_0 - d_0. The difference from the previous case is that producers receive P_0 for each unit of the good purchased, whereas consumers pay $P^* = P_0(1+t)$: as a result of the distortion (the excise tax in this case) there is a difference between the price that producers receive and the price that consumers pay. As the government demand for the good increases to s_1-d_1, it bids up its price from P_0 to P_1. The higher price induces consumers to reduce their purchases and producers to increase their production. As a result of the reduced consumption, the government loses tax revenue (not offset by private gain) in an amount equal to $(P^* - P_0)(d_0 - d_1)$.[6] In addition, consumers reduce their consumption in an

[6] When the tax in question is a given amount, T, per unit of product (say, 10 cents per kilo), the extra cost associated with displaced demand is simply T–D. However, when the tax is ad valorem, the change in government revenue is $t(p_1q_1 - p_oq_o)$, which in turn is approximately equal to $p_o t$– + $q_o t$–p. In this case it is only the first term that enters into the calculation of the economic cost. The gain or loss to the government arising from $q_o t$–p is offset by opposite losses or gains to demanders and suppliers.

amount valued at $P_0(d_0 - d_1)$. Finally, consumers also lose consumer's surplus in an amount equal to $\left(P_1^* - P_0^*\right)\left(d_0 - d_1\right)$. Society then, places a value on the goods released to the project equal to the sum of these three amounts, which is equal to the shaded area under the demand curve D(P*). Similarly, the cost of producing the extra units of the good for the project's use is given by the shaded area under the supply curve. The total cost to society of the goods transferred to the project, then, is given by the shaded areas under the demand and supply curves:

$$P^*\Delta D + 1/2\Delta P^*\Delta D + P\Delta S + 1/2\Delta P\Delta S \qquad (6)$$

Ignoring again the loss in consumer surplus and the gain in producer surplus and expressing the unit cost to society in terms of elasticities, we obtain an expression similar to (5):

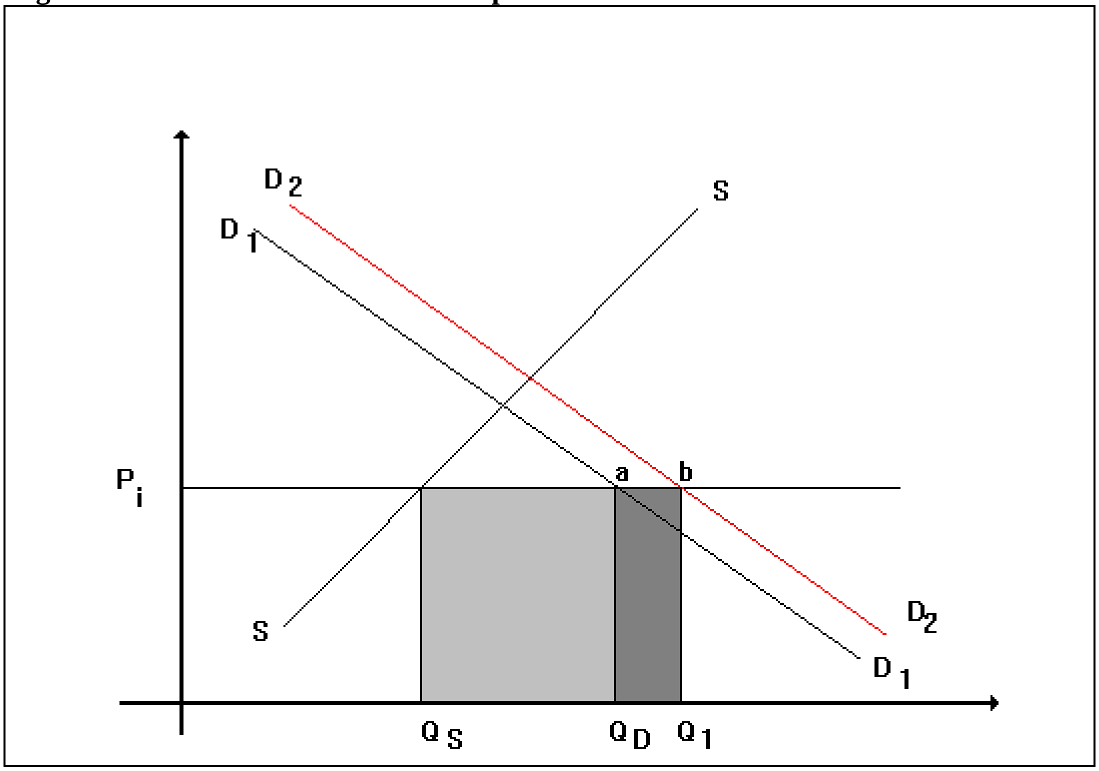
$$UV = P^*\left(\frac{\eta d_0}{\eta d_0 + \varepsilon s_0}\right) + P\left(\frac{\varepsilon s_0}{\eta d_0 + \varepsilon s_0}\right) \qquad (7)$$

30. The interpretation of equation 7 is straightforward: the unit value (UV) to society of each unit of the good diverted from the private sector to the government project is equal to the weighted average of the price actually paid by consumers and the price perceived by producers. The weights are proportional to the elasticities of demand and supply and to the original quantities supplied and demanded. If the demand is totally inelastic ($\eta = 0$), consumers are not going to reduce their consumption of the good and the project's additional demand will have to be satisfied entirely with additional production, in which case the relevant price is the supply price. If, on the other hand, supply is totally inelastic ($\varepsilon = 0$), then the project's additional demand will have to come from forgone consumption, in which case the relevant price is the demand price. In most cases, neither supply nor demand will be totally inelastic and the relevant price will be a weighted average between the two prices. This basic conceptual framework can be applied to measure the social opportunity cost of nontraded goods, traded goods, capital, foreign exchange, and labor.

Traded Goods

31. Traded goods can be seen as a special case of the most general case depicted in figure TA.2, especially when we are dealing with a small country that is a price taker in the world market. Let us first consider an import that is also produced domestically, as shown in figure TA.3.

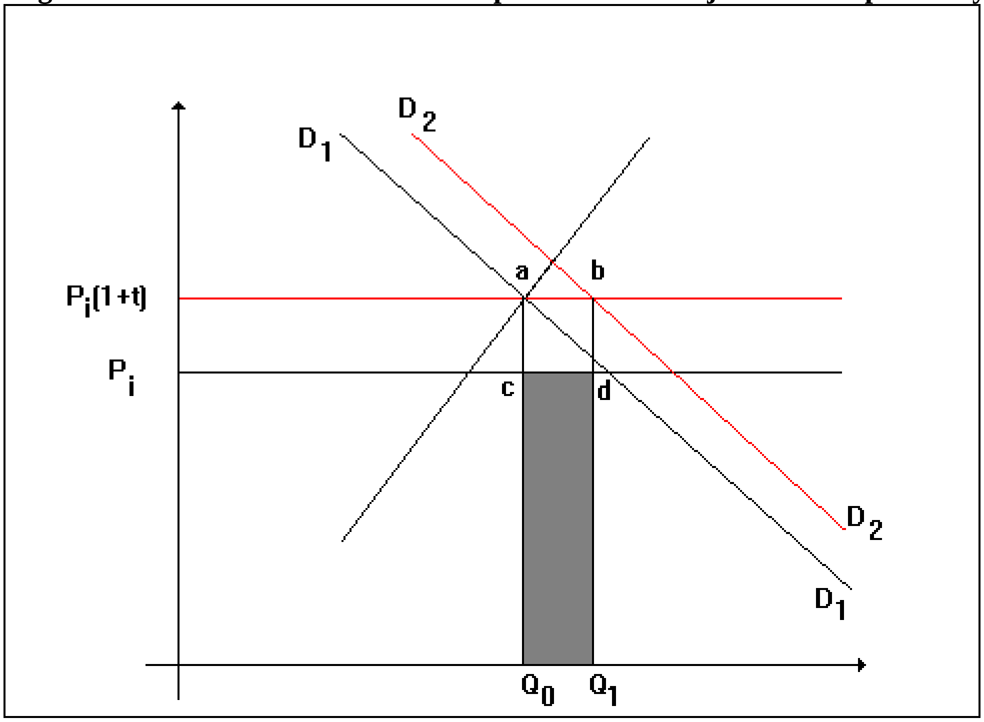
Figure TA.3. Economic Price of an Imported Good



In this situation, the country consumes Q_D units of the good, of which domestic production satisfies Q_S and imports supply the difference (Q_D-Q_S). As the government bids for goods, domestic demand increases from D_1D_1 to D_2D_2; but because the good is an import and the country is a price taker, the additional demand is satisfied with additional imports, which increase by the amount Q_1-Q_D. The total cost to society of the additional consumption is the area given by the rectangle abQ_1Q_D, and the unit cost by the import price, P_i. As discussed in chapter 5, the relevant price is not necessarily the international price of the good, but the import-parity price, i.e., the border price adjusted for transport costs. Similar analysis leads to the conclusion that the relevant price for an export good is the export price or export-parity price. The same result obtains if we use equation 7 above. In the case of a small, price-taker country, the elasticity of supply is infinite. As ϵ tends to infinity, the weight of P* tends to zero and the weight of P tends to unity.

32. If the good is subject to an import duty, then there are two possible cases. First, domestic prices may be equal to the border price cum duty, or the domestic price may be below the border price cum duty. We consider first the case where domestic prices are equal to the border price augmented by the duty, as shown in figure TA.4. In this situation the border price is P_i and the domestic price is $P_i(1+t)$, where t is the duty rate. By construction, there are no imports. The domestic price is determined by the intersection of the domestic demand and supply curves. This domestic price is assumed to be exactly equal to the tariff-augmented border price Under these conditions, the initial equilibrium is Q_o (initially, we assume no government imports).

Figure TA.4. Economic Price of an Imported Good Subject to an Import Duty



New projects will shift domestic demand from D_1D_1 to D_2D_2. In this case the additional demand is satisfied entirely from imports. The original consumers do not reduce their level of consumption, and domestic production remains unchanged. The cost of satisfying the additional demand for the project is given by the area cdQ_1Q_o and is equal to the foreign exchange cost of the additional imports. The area abdc is equal to the additional duties collected by the government. The project entity, of course, pays the import duty to the government. While this is a cost to the project entity, it is not a cost to society: the duty is a transfer from one government entity to another one, or from the project entity to the central government. The opportunity cost to society of satisfying the additional demand is given by foreign exchange used to import the good, that is, the area cdQ_1Q_o. The *unit* cost is given by P_i. The financial cost of each unit of the good to the project entity, however, is $P_i(1+t)$. The difference in cost, of course, is the import duty.[7]

Nontraded, but Tradeable, Goods

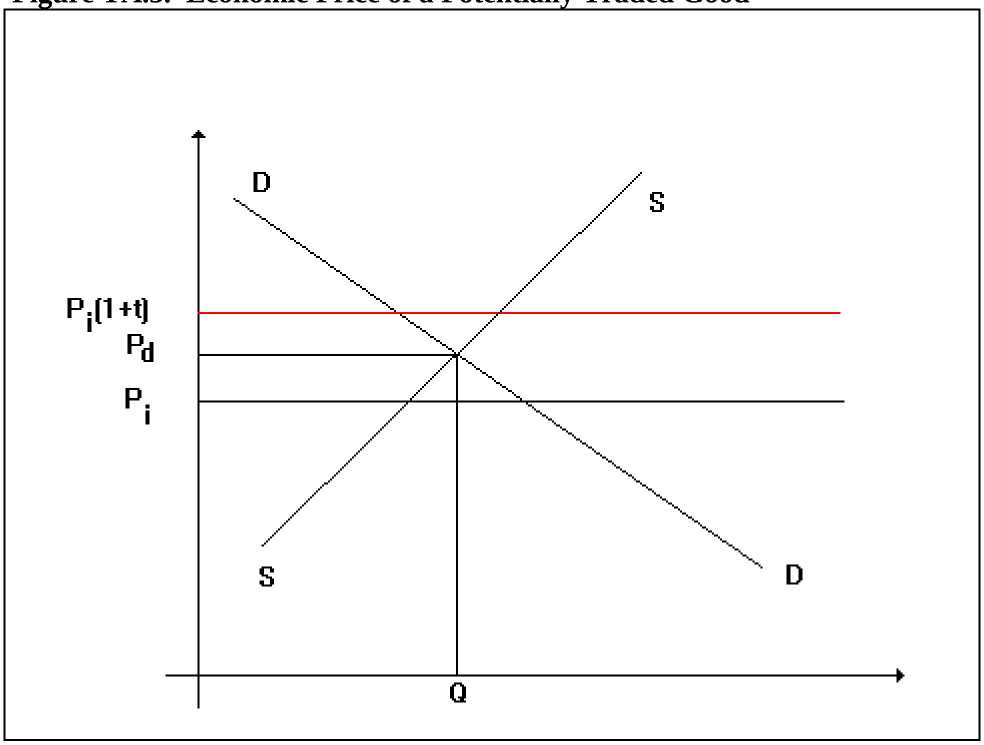
33. The tradition in Bank analysis has been to treat tradeable goods like traded goods and to use the import- or export-parity price for tradeable goods, even if they are not traded. The justification for using the import- or export-parity price as the shadow price of tradeable goods is similar to one used for traded goods, discussed in the previous section.

34. There are some rare cases where the domestic price of a nontraded, but tradeable, good is below the border price plus the tariff, that is, there is "water in the tariff." Figure TA.5 depicts such a situation. The border price in this case is P_i, the domestic price is P_d, and the tariff-

[7] If the price is denominated in foreign currency, then the price in domestic currency is equal to the foreign currency price times the shadow exchange rate.

augmented price is $P_i(1+t)$. If as a result of a new project the demand curve shifts slightly to the right and the domestic price rises, the additional quantity demanded will be met partly through a reduction of consumption of original consumers, partly by an increase in supply. The cost to society of each additional unit of the good will be P_d. Many experts think that the correct shadow price should still be P_i because it would clearly be the opportunity cost to the country if there were no import duty. Others think that if the government is expected to maintain the tariff, then the shadow price should be P_d, unless the tariff is expected to be reduced or abolished in the near future, in which case the correct shadow price should be P_i. The correct way to deal with the problem is to use P_d for as long as the government maintains the tariff. Using P_i *overestimates benefits* if the good is an input of the project and *underestimates benefits* if the good is an output of the project.

Figure TA.5. Economic Price of a Potentially Traded Good



35. An intermediate case arises when the import and domestic goods are close, but not perfect substitutes, and the tariff is not prohibitive. In these cases, domestic production and imports coexist. In these cases, the economic price of the good is a weighted average of the net-of-the-tariff price of the import good and the price of the domestic good. As in previous cases, the weights depend upon the shares and the elasticities of supply and demand of the two goods.

Nontradeable Goods

36. In some countries certain goods cannot be traded for various reasons. One of the most common barriers is transport costs: the cost of producing the good domestically is lower than the price of imports plus transport costs. At the same time, the cost of domestic production plus transport costs makes it unprofitable to export, rendering the good nontradeable for that particular country. In Zimbabwe, for example, steel might be such a good. Because Zimbabwe is landlocked, domestic production enjoys natural protection, but at the same time exports are

unprofitable. If a project in Zimbabwe uses steel, the appropriate price for social evaluation depends on whether the additional demand is satisfied from a reduction of existing demand or from additional supply. Conceptually, the case is similar to the one shown in figure TA.5; the only difference is that P_i would indicate the export price (net of transport costs), and $P_i(1+t)$ would indicate the import price plus transport costs: the domestic price is lower than the import price but higher than the export price (net of transport costs).

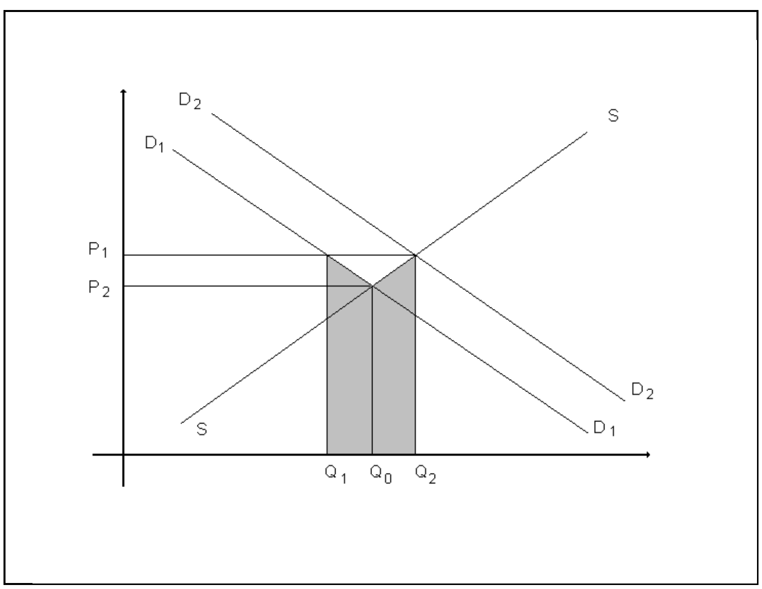
The Shadow Exchange Rate

37. The same principles developed above may be applied to the calculation of the shadow price of foreign exchange. In a distortion-free economy, this value is given by the market-determined price of foreign exchange. Most economies, however, are not distortion-free and the shadow price is not generally equal to the market-determined price.

Distortion-Free Case

38. For purposes of illustration, consider first the case of a distortion-free economy. The price of foreign exchange is determined by the intersection of the demand and supply curve for foreign exchange, that is, by the country's demand for imports and supply of exports. In this economy, the initiation of a project that uses foreign exchange will displace the demand for foreign exchange ever so slightly, causing the *real* price of foreign exchange to rise (even if the *nominal* price is fixed), as shown in figure TA.6. At the new price, the quantity demanded of foreign exchange will fall (freeing an amount of foreign exchange equal to $Q_0 - Q_1$) and the quantity supplied will rise (generating an amount of foreign exchange equal to $Q_2 - Q_0$). The *value* to society of the foreign exchange available will be equal to the sum of the areas under the demand and the supply curves. The *unit* value of foreign exchange will be equal to the sum of the areas divided by the quantity of foreign exchange released, which in this case is equal to the market price of foreign exchange.

Figure TA.6. Economic Price of Foreign Exchange in an Undistorted Market

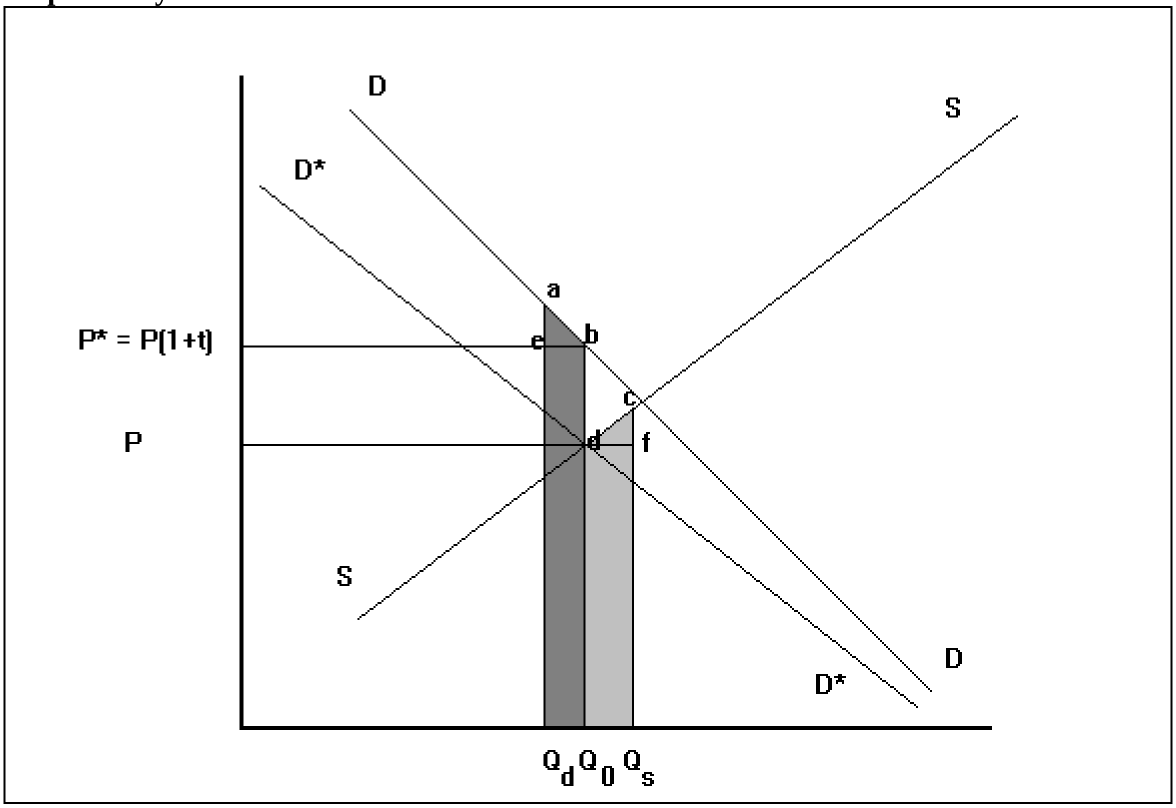


Uniform Import Duty

39. If there is a uniform import duty, the demand curve for foreign exchange will be lower by the amount of the duty, as shown in figure TA.7. In this case, an exporter would receive P units of

domestic currency for every unit of foreign exchange earned. An importer, however, would have to surrender P* = P(1+t) units of domestic currency for every unit of foreign exchange imported, where t stands for the import duty rate. In this case, the effective price of foreign exchange for the importer is higher than for the exporter by an amount equal to the import duty paid. Which of the two prices represents the value of foreign exchange to society, the price that importers are willing to pay or the price that exporters receive?

Figure TA.7. Economic Price of Foreign Exchange when Imports are Subject to a Uniform Import Duty



40. The answer depends on how the quantities demanded and supplied of foreign exchange react in response to a price change. If supply is totally inelastic and the net result of a price rise would be a fall in the quantity demanded of foreign exchange, then P* would be the relevant price. If the demand is totally inelastic but supply is not, then the relevant price would be P. In most cases, neither demand nor supply is totally inelastic and the shadow price of foreign exchange is a weighted average of P* and P, where the weights depend on the relative elasticities of demand and supply:

$$SER = wP + w^*P^* \qquad (8)$$

where w and w* are the weights, $w = \eta/(\eta + \varepsilon)$ and $w^* = 1 - w$, and η stands for the demand elasticity for imports and ε for the supply elasticity of exports.

41. At price P, the demand and supply for foreign exchange is Q_0. Importers pay P* = P(1+t) and exporters receive P. If the price of foreign exchange were to rise (the new demand curve has

been omitted to avoid cluttering the diagram), the demand for foreign exchange would fall to Q_d and the supply would rise to Q_s. The magnitude of these two quantities would depend on the elasticities of supply and demand. The total value of the foreign exchange given up by importers would be the shaded area under the demand curve, abQ_oQ_d, and the total cost of generating the increased exports (Q_s-Q_o) would be given by the shaded area under the supply curve, cdQ_oQ_s. The *unit* value of foreign exchange would be the sum of the two areas divided by the quantity Q_s-Q_d, which for very small changes can be shown to be a weighted average of P and P*, as discussed in the previous sections.

Multiple Import Duties

42. If there are multiple import duties, the principles for calculating the shadow price of foreign exchange are the same, but the calculations are a bit more involved. Suppose that there are four types of import duties falling on four different types of goods. The shadow price of foreign exchange would then be a weighted average of the different demand and supply prices of the various imports and exports:

$$SWR = w_1P_1 + w_2P_2 + w_3P_3 + w_4P_4 + w_eP_e \qquad (9)$$

As before, the weights are a function of the quantities imported and exported and of the elasticities of demand for the various imports and the elasticities of supply for the various exports:

$$w_i^m = \frac{\eta_i d_i}{\sum(\eta_i d_i + \varepsilon_i s_i)} \text{ and } w_i^x = \frac{\varepsilon_i d_i}{\sum(\eta_i d_i + \varepsilon_i s_i)} \qquad 10)$$

where w_i^m stands for the weight of the price of the ith import good, w_i^x for the weight of the price of the ith export , η_i for the elasticity of demand of the ith good with respect to its own price, d_i the quantity imported of the ith good, s_i the quantity exported of the ith good, and ε_i for the price elasticity of supply of the ith export.[8]

43. To illustrate the basic principles of the approach, consider the following example. Let us assume that the country levies four tariff rates on imports (100%, 50%, 20%, 0%) and that the domestic price reflects the duty-augmented border price, so that for every unit of foreign exchange spent on the ith good, the equivalent amount of domestic currency is given by the official exchange augmented by the tariff falling on the ith good. We also assume that exports are exempt from export duties and receive no subsidies. Let us finally suppose that the official exchange rate is 10:1, that total imports amount to $1,000 and that exports amount to $800. The basic data can then be summarized as follows:

Category	M_1	M_2	M_3	M_4	*X*
Duty rate (%)	100	50	20	0	0
Domestic price per unit of foreign exchange	20	15	12	10	10
Volume in $	300	200	300	200	800

8 It should be mentioned that these are not ordinary elasticities, but elasticities that measure the response in demand when *all* the prices of imports change as a result of changes in the exchange rate.

44. As a first approximation to the social opportunity cost of foreign exchange we can presume that the elasticities of demand and supply are equal, in which case the weights depend solely on the proportion of the import good as a percent of total trade:

$$W_i = \frac{M_i}{\sum_i M_i + X} \qquad (12)$$

This would yield the following estimate:

SER= 20x0.17 + 15x0.11 + 12x0.17 + 10x 0.11 + 10x.44 = 12.59

As a second approximation, we can use rough estimates of the ratios of elasticities. Suppose that we estimate the supply of exports to be totally inelastic and the demand for imports of M_4 to be totally inelastic also, we have $\eta_4 = \varepsilon = 0$. Assume that the elasticity of the least elastic good, say M_1, is unitary and that we estimate the import demand elasticity of M_2 to be twice as large as that of M_1 and that of M_1 to be twice as large as that of M_3, we have:

$$\eta_1 = 2$$
$$\eta_2 = 4$$
$$\eta_3 = 1$$
$$\eta_4 = 0$$
$$\varepsilon = 0$$

The new weights, then, would be w_1 = .36, w_2 = .46, and w_3 = .18, and the revised estimate of the SER would be:

SER = 20x0.36 + 14x0.46 +12x0.18 = 15.80

It should be noted that it is not necessary to know the values of the elasticities; it is only necessary to have an approximate knowledge of their *ratios*, as in the example above. If we multiply all the values of the elasticities by some factor, sayΦ, the values of the weights and of the SER remained the same. Box 1 shows the application of these concepts in India.

Quantitative Restrictions

45. In principle, quantitative restrictions may be handled in the same manner as import duties: their effect is to raise the demand value of foreign exchange above the official rate. If to provide foreign exchange to a project the government deprives other users of foreign exchange, then the opportunity cost of foreign exchange is the value placed by those deprived on the amounts of which they are being deprived. In these cases the empirical problems involved in estimating the value are formidable and the estimates become very crude indeed.

46. In some cases the costs of refining the estimates may not be worth the trouble and sensitivity analysis may be of use. If the NPV of the project remains positive regardless of the value of foreign exchange (within some plausible values, of course), then it is not worth the trouble estimating the shadow exchange rate with precision. If the NPV is highly sensitive, then it is worthwhile refining the estimates. For every type of good, one possible lower bound might be the

Box TA.1. Shadow Price of Foreign Exchange in India

The Chukha hydroelectric project was built by India in Bhutan. India provided all the capital and in turn was to receive the electricity generated from the project in excess of Bhutan's demand at much cheaper prices than India's generation cost from alternative sources. To evaluate whether the project made economic sense for India, it was necessary to calculate the shadow price of foreign exchange in India, among other things. The economic evaluation of the project was done by D. N. S. Dhakal and Glenn P. Jenkins (D&J) under the auspices of the Harvard Institute for International Development.

At the time, tea and jute were the main hard currency earning products for India, and the use of foreign exchange was highly regulated. India levied high tariffs on imports but provided no subsidies for exports. Construction of the project coincided with the period of the "oil crisis" when India faced severe foreign exchange shortages that led India to impose quantitative restrictions on imports, further distorting the resource cost of foreign exchange.[1]

D&J did an ex-post estimation of the SER, starting with the market exchange rate. They estimated duties as a percent of imports to augment the market rate to arrive at the effective exchange rate for imports (Pm). The effective exchange rate for exports (Px) was the same as the market rate because exports were neither subsidized nor taxed. To estimate the weights, D&J used a single value for the import elasticity (1.5) and a single value for the export elasticity (0.5). In their opinion, these assumptions closely reflected the Indian situation of low export potential and high demand for imports. To arrive at the weights, D&J multiplied the volume of exports by the assumed export elasticity and the volume of imports by the assumed import elasticity. They then calculated the ratios of each quantity to their sum to arrive at the weights. Finally they weighed Px and Pm by their respective weights to arrive at the SER. They estimated a value for each of the years in which the project was under implementation and obtained a series of shadow prices for the years 1976 through 1985, when most of the importing was done for the project.

Items 76/77	*77/78*	*78/79*	*79/80*	*80/81*	*81/82*	*82/83*	*83/84*	*84/85*	
Exchange rate	8.96	8.74	8.19	8.13	7.86	8.66	9.46	10.10	11.36
Exports ($ billion)	61.4	66.4	71.2	83.4	90.3	102.6	116.7	132.4	159.6
Imports ($ billion)	56.1	65.2	74.2	100.9	136	148.2	158.1	176.1	195.3
Import duties collected ($ billion)	15.95	21.97	27.96	32.92	42.39	50.52	55.01	69.59	95.25
Implicit tariff (duties as % of imports)	28.4	33.7	37.7	32.6	31.2	34.1	34.8	39.5	48.8
Subsidies	0	0	0	0	0	0	0	0	0
Effective exchange rates									
For exports (Px)	8.96	8.74	8.19	8.13	7.86	8.66	9.46	10.1	11.36
For imports (Pm)	11.51	11.68	11.28	10.78	10.31	11.61	12.74	14.09	16.90
Weights									
For Px (%)	26.7	25.3	24.2	21.6	18.1	18.8	19.7	20.0	21.4
For Pm (%)	73.3	74.7	75.8	78.4	81.9	81.3	80.3	80.0	78.6
Shadow exchange rate	10.83	10.94	10.53	10.20	9.87	11.06	12.10	13.29	15.71
Conversion factor	1.21	1.25	1.29	1.26	1.26	1.28	1.28	1.32	1.38

Source: Dhakal and Jenkins (1991).

[1] Because of quantitative restrictions on imports, there was an implicit tariff on imported goods. The SER was therefore underestimated because the implicit tariff increased the effective exchange rate for imports. However, because the share of foreign exchange in the total investment was small, its underestimation was deemed unlikely to distort the estimate of minimum benefits for India.

tariff-augmented price, because those who receive a quota will pay as much in domestic currency for every unit of foreign exchange received. An upper bound may be the ratio of the price of goods in the domestic market to their border price.

Exchange Rate Adjustment

47. It is very unlikely for the real exchange rate of any country to remain constant over long periods (see, for example, table TA.6). Because of the impact that the real exchange rate may have on the relative prices of tradeables and nontradeables—and hence on the NPV of a project—time and effort spent estimating the path that the real exchange rate may follow are time and effort extremely well spent.

Table TA.6. Selected Real Exchange Rates, 1975-93
(1975 = 100)

Country	*1980*	*1985*	*1990*	*1993*	*Coefficient of variation (%)*
Argentina	32.25	74.62	61.70	35.08	37
Brazil	100.77	200.86	77.89	75.98	30
Chile	79.05	121.35	137.36	119.93	25
China	112.68	171.96	246.21	231.22	35
Colombia	81.14	85.10	143.61	126.45	27
Congo	100.16	119.44	98.02	95.16	9
Ecuador	92.01	72.22	176.54	137.79	33
India	123.29	118.35	163.10	218.39	23
Indonesia	121.72	129.22	209.11	191.07	33
Kenya	87.59	98.87	122.81	142.96	14
Malaysia	116.01	100.40	145.90	127.87	14
Mauritius	93.46	115.85	113.95	113.84	10
Mexico	125.57	131.70	149.24	110.64	20
Nigeria	66.72	43.25	193.29	215.04	60
Pakistan	104.71	113.71	162.88	172.02	23
Philippines	92.29	85.57	111.98	93.46	10
Rwanda	93.01	70.52	75.14	92.71	14
Senegal	112.97	130.63	114.60	127.09	10
Sri Lanka	233.06	207.25	247.76	222.79	21
Tanzania	94.19	51.36	245.76	288.34	55
Thailand	100.52	99.96	113.53	102.56	9
Tunisia	114.11	141.85	157.35	157.66	17
Turkey	109.62	139.77	120.15	112.32	21
Uganda	NA	183.40	344.01	481.68	54

[a] An *increase* in the index indicates real depreciation.
Source: IMF *International Financial Statistics Yearbook, 1994.*

48. Changes in the real exchange rate depend upon three factors: shifts in the demand for imports and the supply of exports, changes in government policy, and changes in capital movements. Accordingly, there are three key questions to be borne in mind when attempting to

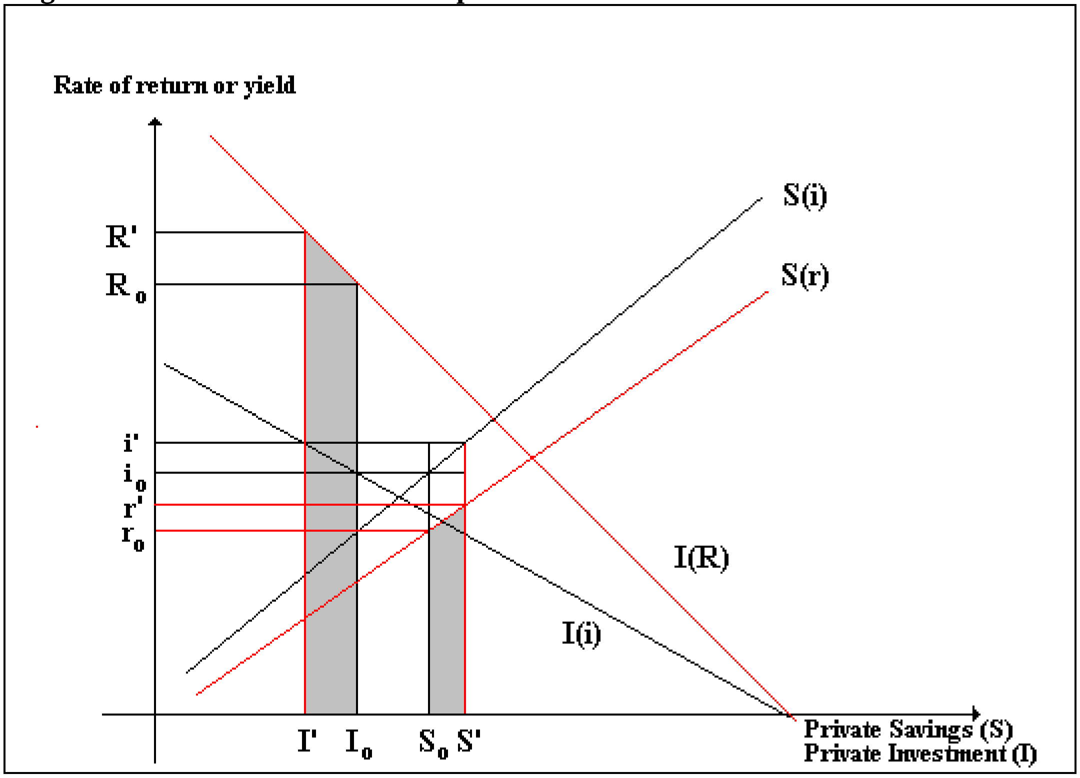
estimate movements of the exchange rate relative to other prices. First, what are the likely trends in the basic demand and supply of exports? Are incomes rising and, if so, is the demand for imports rising also? Is the composition of exports changing? Second, are there any transitory factors pushing the exchange rate up or down? Are the prices of key exports extraordinarily high? Are capital movements extraordinarily high? Are debt-service burdens temporarily high? Third, are there any likely changes in government policy that will tend to make the exchange rate higher or lower? For example, is there any intention of reducing tariffs, or nontariff barriers? Assessing the implications of all of these questions is not an easy task but is extremely important one in projecting the course of the real exchange rate and hence for project evaluation.

The Opportunity Cost of Capital

49. Traditionally, the Bank has used 10-12 percent as the discount rate for all Bank-financed projects. This rate is but a rationing device for World Bank funds and should not be construed to reflect the cost of capital in the borrowing countries. Task managers are free to use a higher or lower discount rate where warranted, as long as they provide a sound justification. A discount rate lower than 10 percent might be difficult to justify. Most research has shown that the cost of capital for developing countries is higher than 10 percent. Nevertheless, for the sake of completeness, we present here the conceptual framework for determining the opportunity cost of capital.

50. To keep the presentation simple, we first consider a country without access to international capital markets. We assume that the country levies a corporate income tax and a personal income tax. In figure TA.8, I(R) depicts the demand curve for investible funds as a function of the pretax cost of capital R, assuming full employment of the economy's resources. Investment will presumably be carried to the point where its expected marginal productivity will be equal to the cost of capital. I(R), then, represents the marginal productivity of investment. For purposes of this example, we assume that corporations are subject to an income tax. Private returns, then, are lower than social returns by the amount of the tax. I(i) represents the after-tax yield on private investment. The difference between I(i) and I(R) is, of course, the income tax—assumed to be a constant percentage.

Figure TA.8. Economic Price of Capital



Similarly, S(i) depicts private sector investment as a function of the market. S(i) shows the relationship between the volume of savings per unit of time and the market interest rate. S(r) depicts the after-personal-income-tax yield on savings (r). Thus, while S(r) shows the volume of savings that savers are willing to set aside at a given post-tax yield, S(i) shows the relationship between savings and the market interest rate (i) that must obtain in order for savers to receive a post-tax yield (r). Initially we assume that government borrows an amount equal to the difference between private savings and private investment: S_o-I_o. The market equilibrium interest rate is given by i_o. If the government decides to borrow an amount equal to S'-I', the additional demand will push up the interest rate to i'. As in the case of cement (see figure TA.1) where the effect of an increase in its price reduced the demand and increased the supply, the net effect of a higher interest rate will be to reduce the amount of private investment in the amount I_o- I' and increase private savings from S_o to S'. To determine the social opportunity cost of funds, we must determine the value that society places on the investment forgone to release funds to the government and the consumption forgone to increase savings from S_o to S'_d

51. As in the cases discussed before, the shaded areas under the demand and supply curves give the cost to society of the capital borrowed by the government. The social cost of diverting funds from the private to the public sector can be broken down into three parts: (a) forgone consumer surplus not offset by increased taxes; (b) forgone taxes not offset by private gains; and (c) forgone (after-tax) income by private investors. Similarly, the area $_o$r!S!S$_o$ represents the social cost to society of the increased savings. Equation 7 in this case becomes

$$OCC = r_o\left(\frac{\varepsilon S_0}{\varepsilon S_0 - \eta I_0}\right) + R_o\left(\frac{-\eta I_0}{\varepsilon S_0 - \eta I_0}\right) \qquad (11)$$

52. Consider the following example. Let us suppose that in the country in question there is no inflation and only one market for investible funds. Suppose that there is only one corporate tax rate, say 40 percent, that the income tax applicable on savings is 45 percent, and that the market interest rate is 10 percent per year. Assume further that the volume of savings is 120 units of domestic currency and that the volume of private investment is 100 units (government borrowing is 20 units). In terms of figure TA.8, this means that I_0 = 100 and that S_0 = 120. Because the corporate tax rate is 40 percent, the pretax corporate return on equity, R_0, is 16.67 = 10/(1 - 0.4). Similarly, the after-tax return on investment, r_0, is 6.5 = 10x(1-0.45).

53. As a first approximation to the opportunity cost of capital, we assume that the elasticity of savings and investment with respect to the interest rate are the same. In this case the weights depend solely on the proportion of investment and savings as a percent of the sum of investment plus savings:

$$W_i = \frac{I_0}{S_0 + I_0} \tag{12}$$

$$W_s = \frac{S_0}{S_0 + I_0} \tag{13}$$

in which case the OCC would be

$$OCC = 16.67x0.45 + 6.5x0.55 = 11.2$$

As a second approximation, we again use rough estimates of the elasticity of demand for investment and of supply of savings with respect to the interest rate. We do not need to know the elasticities, but a rough a idea of ratios would do. Say that the elasticity of demand for investment is four times as large as the elasticity of supply of savings. Our new weights would then be

$$Ws = \frac{4x100}{4x100 + 120} = 0.769$$

and $W_i = 1 - W_s = 0.231$. The new estimate of the OCC would then be

$$OCC = 16.67x0.769 + 6.5x0.231 = 14.3$$

As in the case of the shadow exchange rate, it is not necessary to know the precise values of the elasticities—a rough idea of the relative values is adequate.

54. A multiplicity of tax rates on corporate entities and a graduated income tax complicate matters, but the principles remain the same. Suppose that there are two investment sectors: corporations, subject to a 40-percent income tax, and noncorporate entities, exempt from taxes. Suppose also that there are three classes of savers, one with a marginal income tax rate of 15 percent, another with a marginal income tax rate of 30-percent, and a third with a marginal tax rate of 45 percent. We also assume that the elasticity of investment with respect to the interest rate is higher for the corporate than for the noncorporate sector and in turn the elasticity of savers with respect to the interest rate is lower the higher the income. The basic data are shown below:

Sector	*Tax rate (%)*	*Volume ($)*	*Relevant return (%)*	*Elasticity*
Corporate	0.40	150	16.67=10/(1-0.4)	-2.0
Noncorporate	0.00	50	10.00	-1.5
Total investment		150		
Savers				
Low-income	0.15	70	8.50=10 x (1-0.15)	1.0
Middle-income	0.30	100	7.00=10 x (1-0.30)	0.7
High-income	0.40	150	6.00=10 x (1-0.4)	0.5
Total savings		220		

As a first approximation to the OCC, we assume that the elasticities are all the same. This would imply that when the interest rate rises in response to government borrowing, each of the investment sectors reduces its demand for funds in proportion to its share in the total pool. Likewise, each group of savers increases its savings in proportion to its present contribution. The OCC, then, is a weighted average of the pretax returns to investment in the private sector (the marginal productivity of capital in the private sector) and the post-tax returns to private savers (the time preference in consumption for different groups of savers), with the weights equal to the proportion of funds that the particular sector contributes to the total:

$$OCC = 16.67x0.29 + 10.00x0.10 + 8.50x0.13 + 7.00x.0.19 + 6.00x0.29 = 9.99$$

55. We know, of course, that each investment sector is going to react differently for a given change in the interest rate, and that savers are also going to react differently. In short, we need to take into account the various demand and supply elasticities. If we take the elasticities into account and re-calculate the OCC, we obtain:

$$OCC = 16.67x0.50 + 10.00x0.13 + 8.50x0.12 + 7.00x0.12 + 6.00x0.13 = 12.28$$

56. Foreign borrowing is often an important source of funds that can and should be taken into account when calculating the OCC. As suppliers of funds, foreign savers can be included in the broad class of savers and entered into the analysis just like any other saver. If foreign savers are an important source of funds and the elasticity of supply of foreign savers is very high, the OCC might just be equal to the cost of borrowing abroad. This result can be seen if we introduce foreign borrowing into equation 12:

$$\text{OCC} = r\left(\frac{\varepsilon S_o}{\varepsilon S_0 - \eta I_0 + \mu F_0}\right) + R\left(\frac{-\eta I_0}{\varepsilon S_0 - \eta I_0 + \mu F_0}\right) + f\left(\frac{\mu F_o}{\varepsilon S_0 - \eta I_0 + \mu F_0}\right) \qquad (14)$$

If μ, the elasticity of supply of foreign funds, is very large, the relative weight of the cost of borrowing funds, f, will dominate equation 15. This is the monetary counterpart of the discussion in paras. 31 and 32 above concerning the opportunity cost of traded goods: for a small country facing an infinitely elastic supply of funds, the OCC will be given by the cost of borrowing abroad. If the country faces a less than infinitely elastic supply of funds, the marginal cost of funds will be equal to $P(1 + 1/\mu)$, where P stands for the average cost of funds.

57. All of the above rates should be in real terms. If the values appear in nominal terms, they should be adjusted for inflation. The general formula for adjusting for inflation is

$$R_r = \frac{R_n - i}{(1 + i)}, \qquad (15)$$

where R_r denotes the real rate, R_n the nominal rate, and i the expected inflation rate.

Box TA.2. Opportunity Cost of Capital in Indonesia, 1993

Jenkins and El-Hifnawi (J&H) estimated the opportunity cost of capital for Indonesia in 1992. Their calculations are summarized in the table below. J&H began by separating investors and savers into households, business, government, and foreign savers. From the national accounts, they calculated the shares of investment and savings for each group, as shown in column 1.

Next they estimated the marginal nominal return on investment for each group on the assumption that at the margin the return to investment is equal to the cost of borrowing. For households, J&H estimated the nominal after-tax return on investment at 23%—the average rate for loans to small-scale enterprises—and the marginal nominal return for business at 19%. Government investment was assumed to be independent of the interest rate.

On the savings side, for households J&H used the expected 6-month deposit rate, 16%. For business, they estimated the return on equity at 18.9%. Government savings was assumed to be independent of the interest rate. Finally, J&H estimated the cost of borrowing abroad at LIBOR plus 3 points, or 9.28%.

Next, J&H calculated the relevant returns for each group (gross returns for investors and net returns for savers). For households, J&H began with the after-tax nominal return, 23%. They estimated the tax paid by assuming that households incur interest expenses equivalent to 30% of total return, that is, that 30% of the total return to households was sheltered from income tax. They estimated the tax burden as [GR -(0.30 x GR)]x 0.15, and expressed the after-tax return as follows: 0.23 = GR - Tax = GR -[GR - (0.30 x GR)] x 0.15. Solving for GR (gross return), they obtained 25.7%. Similarly, for the business sector, they estimated a return of 25.6%: the interest on loans was 19%, the income tax rate 25%, and the VAT equivalent to 10% of profits. J&H then used the following equation to calculate the gross-of-tax nominal return: GR = .19/[(1-VAT) x {(1 - %D) x MTR}], where %D stands for the proportion of interest expense as a percent of gross profit, and MTR for the marginal tax rate. For savers, J&H simply subtracted the tax from the gross return to arrive at the net return. Finally, they adjusted each return for inflation using equation 15. Column 6 shows the real returns for each of the sectors.

For foreign funds, J&H used a weighted average of fixed and variable interest rate loans. For fixed-rate loans they calculated the real rate at 4.07%. For variable-rate loans they assumed that the elasticity of supply was 2 and estimated the share of total foreign borrowing at variable interest rates at 60%. Using the relationship in para. 32, MC = P(1 + 1/e), J&H calculated the marginal real cost of variable rate loans at 6.11%: 4.07 x [1+ 1/2]. J&H then calculated the cost of foreign funds by weighting each rate by its respective share: (4.07%)(0.4) + (6.11%)(0.6) = 5.3%

Column 7 shows the elasticities that J&H assumed for each sector. Column 8 shows the shares of funds contributed at the margin by each of the sectors in response to a rise in interest rates. Finally, column 9 shows the returns weighted by the shares in column 8. The last row shows the opportunity cost of capital for Indonesia as derived by J&H.

Sector	*Share (%)* (1)	*Nominal return (%)* (2)	*Income tax rate (%)* (3)	*Relevant return (%)* (4)	*Inflation (%)* (5)	*Real return (%)* (6)	*Elasticity (%)* (7)	W_i *(%)* (8)	*Weighted Return (%)* (9)
Investment sector									
Households	19.7	23	15	25.7	7.5	16.9	-1.0	13.4	2.28
Business	56.8	19	25	25.6	7.5	16.8	-1.0	38.7	6.51
Government	23.5						0.0	0.0	0.0
Savings Sector									
Households	33.6	16	15	13.6	7.5	5.6	0.5	11.5	0.65
Business	41.1	18.9	25	14.2	7.5	6.2	0.5	14.0	0.87
Government	8.9						0.0	0.0	0.0
Foreign	16.4	9.3	0.0	9.3	5.0	5.3	2.0	22.4	1.19
Opportunity Cost of Capital									11.5

Source: Jenkins and El-Hifnawi (1993).

The Shadow Wage Rate

58. The same basic principles can also be applied to the calculation of the social opportunity cost of labor. Their application, however, is vastly more complicated by the huge variations in types of labor, depending on skills, regions within countries, and even individual jobs. It is also complicated by government interventions such as minimum wage legislation, unemployment compensation, and income taxes. Nevertheless, the basic principle—that the value to society of labor diverted to the project is equal to the weighted average of the values placed by society on the different kinds of labor used by the project—can be of practical use here also.

59. We first consider the simplest case of a full employment market with one distortion, an income tax on wages. The cost of labor in this case would be the weighted average of the market wage (which represents the value to the employer of the forgone labor) and the net-of-tax wage received by labor. This simple case gets complex very quickly. Labor may be drawn from regions other than where the project is located, or from other employment. In each case, there may be some external effect. For example, as a result of the transfer of labor from one region to another, taxes may be lost (or gained). There may also be an increase in economic rent, if the newly employed would have been willing to work for less than the going wage.

60. If there is unemployment, the complications multiply. There may be savings of public funds if, for example, unemployment compensation payments fall as a result of the newly created vacancies. The diverted labor may also come from the pool of unemployed, or from the informal sector, etc. In each case, there may be external effects that affect the valuation of labor.

61. The most common type of distortion, of course, is minimum wage legislation. A minimum wage set above the market clearing rate gives rise to unemployment, including what some authors call “quasi-voluntary unemployment,” that is, the pool of unemployed who would be willing to work at the minimum wage, but whose reservation wage is higher than the market-clearing rate. Minimum wage legislation also gives rise to fragmented markets: the “protected market” (or markets), and the free markets. An expansion in the number of jobs in the “protected sector” will draw workers from the free-market sector as well as from the quasi-voluntarily unemployed, leading to an average supply price that will be above the free market rate (but below the minimum wage). To measure all of these effects requires a vast amount of information and may not be worth the trouble if the NPV of the project is not sensitive to the valuation of labor. For these reasons, in this Handbook we suggest a simple, but practical approach based on sensitivity analysis.

62. If the market works fairly efficiently and there is no minimum wage legislation (or unemployment is low), then a good approximation in most cases will be the going wage rate. If there is minimum wage legislation and substantial unemployment, the going wage rate in the protected sector may be an upper bound and the going wage in the unprotected, or free market sector, might be a lower bound. If the NPV is not negative in both cases, then the cost of labor is irrelevant for the decision at hand and there is no need to continue refining the estimates. If the NPV is negative at the minimum wage rate but not at the free-market wage rate, then it might be worthwhile spending on market research to determine the source of labor for the project and using as the shadow wage rate a weighted average of the different wage rates.

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