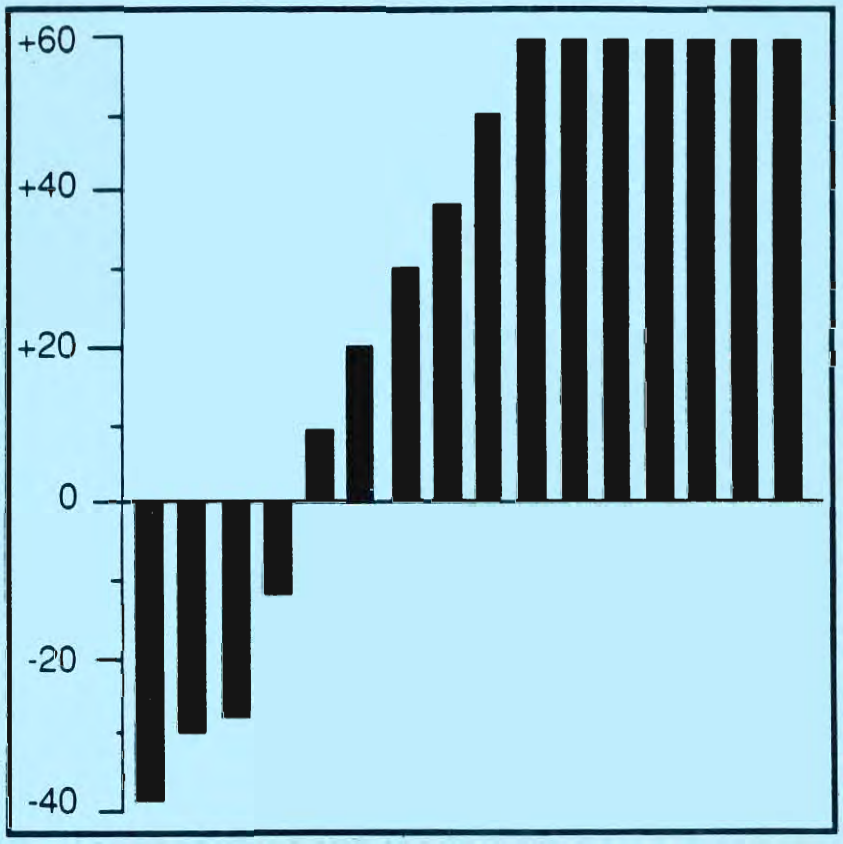
A.I.D.
Manual for Project Economic Analysis



Bureau for Program and Policy Coordination
U.S. Agency for International Development
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A.I.D. MANUAL FOR PROJECT ECONOMIC ANALYSIS

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CHAPTER 1

INTRODUCTION TO PROJECT ECONOMIC ANALYSIS

In all nations, limited resources constrain options for present and future consumption; with developing nations, this constriant is especially severe. Difficult choices must be made among competing uses for these limited resources, and this requires the careful assessment of the trade-off associated with using resources in one way rather than another. Economic analysis offers a method for presenting the attributes of these competing uses in an organized and systematic manner, which assists the decision-makers in setting priorities.

The economic analysis of projects is, however, a partial analysis and, therefore, often appears divorced from the resource allocation process at the national level. The linkage between the two is the use of the opportunity cost principle at the project level which seeks to ensure that resources allocated to a project have no other greater beneficial use in the economic system. The results of economic analyses are then used to define the opportunities available in the economic system to achieve the national goals established to reflect national priorities. National priorities are also reflected in the macroeconomic policies enacted by the nation, which, in turn, establishes the economic environment in which opportunity costs of resources are determined. Project economic analysis and macroeconomic policies are therefore interrelated and, ideally, operate in an iterative fashion. The role of project analysis in developing national goals is further explored in UNIDO (1972). In addition, economic analysis is useful in deciding alternative projects or programs within a sector or region once a decision has been made to allocate a certain amount of investment funds to that sector or region.

1.1 The Project Cycle

The project cycle has several steps which can be presented in numerous ways. A useful delineation would be:

- conceptualization
- prefeasibility
- feasibility
- detailed design
- implementation
- evaluation

The conceptualization step is where a national goal is expressed in terms of more specific objectives with a course of action leading to the accomplishment of those objectives. Ideally, this step would incorporate the knowledge gained from previous project analyses so that national priorities as well as opportunities in all sectors are considered, resulting in a proper

allocation of resources among the sectors. This is known as intersectoral efficiency. While not the primary concern of the economist at the project level, intersectoral efficiency establishes the overall economic environment in which project economic analyses are carried out.

The greatest contribution of project economic analysis in achieving the efficient allocation of resources is in the second and third steps, i.e., prefeasibility and feasibility. The prefeasibility step offers the most freedom to explore alternatives, so it is vital that the economist take an active role. The economist's knowledge of the opportunity costs of resource usage can have a great impact on, for example, the level of imported items and the capital intensity of technologies chosen. The economist can also contribute in analyzing and developing best alternatives without preconceptions. Although it is seldom practical to conduct complete, formal economic analyses of all alternatives, a preliminary analysis can greatly reduce the possibility of selecting an undesirable alternative in lieu of the best. The project identification document (PID) developed at this stage should thoroughly delineate the alternatives investigated and the rationale for the selection of the one recommended.

The range of alternatives is much more restricted in the feasibility stage, and analysis here takes a much more formal tone. Ideally, the project should be free to iterate between the prefeasibility and feasibility stages so that investigation of alternatives is not restricted. The formal project economic analysis included in the project paper (PP) produced at this stage should reaffirm the selection process applied at the PID stage.

In the design stage the economist countinues to play a useful role as the details of the project are worked out. The previous stages, of necessity, used numerous estimates and assumptions of varying quality in the economic analysis. The data procured in the design stage is more precise and should be monitored for conformance to the previous estimates. This is to ensure the economic analysis conducted retains its validity and identifies, for future reference, those estimates and assumptions found to be inaccurate. Also, alternatives are frequently presented in the design stage which must be analyzed from an economic perspective. The implementation stage also requires monitoring by the economist for conformance to original estimates.

The project evaluation stage examines the performance of the project in comparison with the projections made during the previous steps. To be effective, the evaluation must be made on the basis of observable measures. Consideration of this issue at the earliest stages of project planning can ensure that data on these measures are collected after the project implementation is complete. This also relates to the specification of the project objectives.

For example, a health care project may have as its goal the improvement of neonatal care. Its output may be the examination and

advisement of a specified number of expectant mothers with the objective of reducing the infant mortality rate. An effective evaluation of the project would, therefore, require comparisons of the projected versus realized number of expectant mothers advised and a comparison of the reduction in infant mortality rates between participating and nonparticipating expectant mothers to identify effectiveness. The evaluation measures should be developed in the feasibility stage of the project, specifying the actual data to be collected during project activities for the evaluation. Additional discussion on the project cycle can be found in Baum (1978) and Gittinger (1982).

1.2 Relationship of Economic to Other Facets of Analysis

The project economist is one member of a team which may include technical, sociological, environmental, institutional, and managerial components. To perform effectively, the economist must receive information from each element and have the responsibility of incorporating that information in an organized manner. The information should be quantified to the maximum extent possible even if such quantification must be based on assumptions. The other team members are invaluable in ensuring the reasonableness of these assumptions. The economist, in turn, is invaluable in ensuring that the other team members develop their analyses in ways that allow for effective economic appraisal. This includes the collection of relevant data and the explicit statement of all assumptions -- a task with which economists are generally more comfortable. For example, an agronomist may recommend a certain crop for an area to be irrigated based on implicit assumptions of farmer behavior, expected yield, and market acceptability of the crop. The economist can ensure that these assumptions are stated explicitly and examined for reasonableness as well as apprising the agronomist of market factors, such as export potential, of alternative crops.

1.3 Organization of This Manual

This introductory chapter establishes the relationship between project economic analysis and the development process. Chapter II presents the principles to be followed in conducting the analysis. These include the basic approach to be followed, the process of defining the boundaries of the analysis, the identification of costs and benefits, the determination of their value, the measurement of project viability, and the performance of sensitivity and risk analyses. Chapter III takes the principles presented in Chapter II and demonstrates their application using specific numerical examples. Chapter IV discusses issues specific to five sectors: agriculture, transportation, health care, financial, and training and education. Case studies for an agricultural research and development project and a line of credit equity investment to a development finance company are presented.

Also included is a glossary and an annex on cost-effectiveness analysis.

CHAPTER 2

PRINCIPLES OF PROJECT ECONOMIC ANALYSIS

2.1 Basic Approaches to Project Economic Analysis

Several elements are common to all valid approaches to project economic analysis. Given that the perspective taken in economic analysis is that of society as a whole, rather than any specific entity within society, such as an individual, business, or government, the measurement of costs is based on the opportunity cost principle. That is, the cost of using a resource is the loss society will incur from not having that resource available for its best alternative use. In a similar fashion, the value of outputs of a project is based on the society's willingness to pay. Where market prices diverge from these economic definitions of value, economic analysis employs what are known as shadow prices.

Another common element is the application of a "with/without" perspective which results in the estimation of net benefits with and without the project, as opposed to a "before and after" perspective. The difference is that unlike before and after, with/without incorporates the trends and ongoing activities which would exist in the absence of the project.

There are two basic approaches to project economic analysis. The first, adopted by this manual, is the "economic efficiency" approach, and the second is the "social-pricing" approach. The differences between these approaches relate primarily to the extent to which national goals are incorporated into the analysis at the project level. The economic-efficiency approach employs the objective of maximizing national income (where national income is defined as consumption plus changes in wealth assuming that changes in wealth include changes in the levels of natural resource stocks, i.e. environmental assets) and holds that other national goals, such as income redistribution and savings increases, are best addressed by a wide range of macroeconomic policy initiatives such as tax policies. These policies form the economic environment that determines the opportunity costs for project inputs and establishes values for project outputs. Other aspects of the economic efficiency approach used in this manual include the depiction of all values in domestic currency and the use of constant prices.

The social-pricing approach attempts to incorporate the national goals of increased saving and income redistribution explicitly and quantitatively at the project level. This entails the estimation of weights for incomes accruing to low-income versus high-income members of society and for savings versus consumption. The methodology for establishing these weights, in practice, is not well defined and has had only mixed success in application. For these reasons, this manual does not attempt the quantitative

incorporation of these national goals. The first comprehensive presentation of the social-pricing approach can be found in Little and Mirrlees (1968), developed further by Squire and van der Tak (1975), and recently presented by Ray (1984). The interested reader can find a more detailed discussion of the development and reconciliation of the alternative approaches to project economic analysis in Irvin (1978, pp. 61-80).

2.2 Project Definition

Project definition is the process which clearly specifies (1) the objectives of the project in terms of a country's developmental goals, (2) the project's relationship to the overall economic system (which markets it will affect), and (3) delineation of the boundaries of the project. Project boundaries are defined in terms of geography, time, and affected markets. That is, the project is located in a specific geographical area (sometimes projects involve areas which are not adjacent), the project has a starting and ending point, and it will affect certain markets for goods and services, not all of which are quantifiable.

How a project is defined can have a significant effect on the way the analysis is conducted and the quality of the results. For example, consider an irrigation project. The physical output of the project is water for irrigation, but this is a very difficult product to value. A more effective definition would consider the project as an agricultural productivity project, where the physical output, irrigation water, can be analyzed in terms of the increased value of crops produced, for which markets are established and prices readily observable. This way of defining the project looks at the effect the physical output has on the economy. Physical inputs may also impact the economy and environment in ways that are not immediately apparent. For example, the irrigation project might have environmental benefits and costs that occur both within the project area itself or at some distance. Since these impacts also affect social welfare, they should be included in the analysis.

2.2.1 Including All the Impacts

Tracing the impact of physical inputs and outputs through the economy and environment is accomplished by thinking through the causal chain of events that result. In many instances, this chain can be traced through the economy ad infinitum and, therefore, some rule must be applied to define when to stop the process. In this manual, the process will be referred to as the impact transmission mechanism. The rule for determining how far to trace the impact is: stop when a well functioning market is reached. This market can be observed from data on the values society places on the project's impacts. In our irrigation example above, the first market is agriculture, where prices for the crops affected by the project are determined. When environmental effects also occur they should be

valued and included. For some effects well functioning markets exist, for other effects markets do not exist and other techniques must be used to derive values. This will be discussed in more detail later.

To adequately discuss the impact transmission mechanism, there needs to be some way of defining the boundaries of a project. In general, the concept of a project boundary derives from the physical aspect of its geographical area, for example, a farm or farming area, an industrial plant site, or a road and its surrounding land area. But, like many terms used to describe project economic analysis, there really is no strict definition for project boundary that fits all cases. Therefore, it is more important to understand the concept of a project boundary in relation to the other aspects of economic analysis that it affects or is affected by, rather than to specify an exact definition to the concept. In most cases, the physical concept is suitable as a starting point, but, for a more useful definition, we must expand by adding physical inputs and outputs of the project which are largely responsible for the diversity in project characteristics.

The project boundary concept is important because it is the dividing line between direct costs and benefits and externalities. Economic analysis strives to identify and quantify these externalities using the impact transmission mechanism to connect the physical inputs and outputs to the direct costs and benefits. Externalities are discussed in more detail in Section 2.7, while a caveat to the valuation of externalities, the problem for double counting, is discussed in Section 2.4.5.

2.2.2 Level of Aggregation

Another important factor in developing the project definition is the level of aggregation. For example, are individual farms to be analyzed or are farms to be aggregated into an average or "typical" farm? The use of a "typical" farm to represent a diverse range of characteristics at the individual farm level will introduce aggregation bias into the analysis, but at the same time it makes the analysis easier. Project resources must dictate what the limits to detail will be in the analysis.

2.2.3 Multiple Components

Another issue relates to separability of project components of which there are two situations to consider. The first is when a project contains different components, e.g., a manufacturing plant and transmission lines for power, that cannot be successfully implemented as separate projects. The assignment of benefits in this situation cannot be reliably achieved for each component. Even if the two components are funded separately, they should be combined into a single project for analysis. The second instance is when components of a project are separable, i.e., each can be implemented without the other. An urban market development project, for

example, may include various separate components such as a cinema, a hotel and a food-stall complex that are separable. Here, the components should be separated to ensure that uneconomical components are properly identified and appraised. An exception to this second rule exists when project components are technically separable, but have functional interdependencies which cannot be separated. In this case, the components should be analyzed together.

2.2.4 Project Planning Horizon

The project planning horizon defines the beginning and ending points covered by the analysis. The beginning point is coincident with the start of the project, but the ending point is usually somewhat arbitrary. This is because the life of a project may extend beyond the planning horizon, or in some cases, the life of the project may be indefinite. Planning horizons may therefore be shorter than the life of a project, but usually not longer. When establishing a planning horizon, the economic lifetimes of major project components should be considered, but it is rarely justified to have a planning horizon which extends beyond 25 years, with 15 to 20 years preferable. An exception is made when there are major, long lasting environmental costs or benefits. One can either extend the planning horizon to include these or include a "capitalized" value of the stream of benefits or costs that occur after the cut-off date of the project. Because of discounting this value is not infinite. Ignoring it, however, is incorrect and will bias the economic analysis.

In the absence of major long-term environmental effects, there are two reasons for not extending the planning horizon beyond 25 years. First, the discounting process causes future benefits to have diminishing present values the further into the future they are realized. Normally, benefits realized 25 years into the future will not have a significant impact on the appraisal. For example, at a 10% discount rate, any benefit accruing in the 25th year will have a present value of only 9% of its nominal value and in the 50th year only 0.9%. Second, the future becomes increasingly uncertain the more it is projected so that the quality of forecasts beyond 25 years is usually questionable. Extending the planning horizon to 40 or 50 years does not damage the appraisal but it is generally a pointless exercise.

2.3 Assessment of Alternatives

The process of specifying and analyzing alternative methods of achieving the project objectives is one of the most important functions of project economic analysis. The development of alternatives must, of course, be done with the other members of the project team and may include different technical designs (such as capital-intensive versus labor-intensive technologies), different phasings (such as construction of a four-lane road versus a two-lane road expanded to four lanes in five years), different scales (such

as irrigating 10,000 hectares versus 20,000 hectares), or different configurations (such as a large central hospital versus several smaller decentralized facilities). The superior alternative is then always compared with the alternative of not doing the project at all, i.e., "with" is compared to "without."

The number of potential alternatives can be daunting. While the ideal approach would be to conduct a complete economic analysis of each, a more reasonable approach is to isolate the more promising alternatives using magnitude analysis. In certain cases, a version of analysis which concentrates on the differences between the alternatives, such as economic cost effectiveness analysis, can then be performed. The techniques of magnitude analysis and economic cost-effectiveness analysis and when they are applied are discussed in Section 3.2.2 and the Annex, respectively.

2.4 Identification of Costs and Benefits

The key to a sound cost-benefit analysis is the identification of all the project's costs and benefits without including any item twice (double counting). Although identifying costs and benefits might appear to be straightforward, it is often the most difficult part of the analysis. Therefore, a systematic procedure, based on the production function and the impact transmission mechanism, is presented in this manual to correctly identify all the costs and benefits attributable to the project. These costs and benefits are composed of (1) the physical inputs, (2) the final physical outputs, (3) impacts attributable to intermediate physical outputs, and (4) impacts due to externalities. Upon completion of the identification of these inputs, outputs, and impacts, the type of analysis, either cost-benefit or cost-effectiveness, can be determined.

2.4.1 The Production Function

The first step in identifying costs and benefits is the specification of the production function which identifies the physical inputs used by the project and both the final and intermediate physical outputs produced by the project. The process of producing the project's output must be defined, that is, what are the physical inputs such as personnel, facilities, equipment, and supplies which compose a unit of output and in what proportions and amounts are these inputs combined.

It is essential to recognize that the project's outputs can be classified as either a final physical output or intermediate physical output. Intermediate outputs can be distinguished from final outputs in that the desired consequence or outcome for the project has not been achieved with their production. For example, with a family planning project the intermediate physical outputs might be so many IUDs, birth control pills, or diaphragms distributed which must be linked to the desired final impact of

births averted and a reduction in the fertility level. This linkage of intermediate physical output to the final impact, which is the benefit attributable to the project, is accomplished using the impact transmission mechanism.

2.4.2 The Impact Transmission Mechanism

The second step in identifying costs and benefits is the specification of the impact transmission mechanism which identifies the impacts attributable to the project's intermediate physical outputs and the impacts due to externalities --including environment and natural resource effects -- resulting from the project's inputs and outputs. The identification of these impacts with the identification of the physical inputs and final physical outputs using the production function will complete the task of identifying all the project's costs and benefits.

In many projects, the relationship between project activities and the desired outcomes, or outputs, is complex and, in some cases, cannot be specified precisely. For example, in a project where the intermediate output is diagnosis, the medical experts will have to specify the impact transmission mechanism, that is, the link between diagnosis and treatment and the impact on the patient's health, which represents the benefit. The inability to precisely specify this impact transmission mechanism does not necessarily invalidate the analysis of the project because sensitivity analysis can be employed to ascertain whether or not the conclusion of the project analysis is significantly affected by uncertainties, subjective assumptions, and questionable data (see Section 2.11).

If, however, it is impossible to specify the impact transmission mechanism for the intermediate outputs, an economic cost effectiveness analysis is conducted instead of an economic cost-benefit analysis. For example, in the case of the project which involved a diagnostic procedure, if the benefit of increased health for the patient could not be quantified, then the number of accurate tests could be substituted as the measurement to assess cost effectiveness.

Impacts from externalities attributable to the project's inputs and outputs are identified using the impact transmission mechanism. In many instances, externalities result from complex transmission mechanisms. Multiple impacts may be associated with the same input, when both environmental and economic impacts are taken into consideration. For example, an agricultural project that uses herbicides as an input will affect the environment. Road projects will affect local economies whether they are built to improve general transportation or to serve some industrial project. In Chapter 3, the example project involves a logging operation to supply the wood (an input) required by a manufacturing plant. This wood is a physical input that has impact on both the environment through deforestation and the local economy by improving local roads.

Along with the difficulty in identifying all the paths of causality generated from a particular input or output, the final valuation of the impact will also depend on other factors sometimes outside the control of the project. That is, with the irrigation project defined as a productivity project and benefits valued from the increase in the value of crops, there are numerous factors besides the quantity of water available, such as weather and general economic conditions, that will partially determine how much of an increase is actually realized. In addition, the value of offsite effects on the environment, i.e., economic externalities, should be included in the analysis as well as on-site benefits and costs. Tracing the impact transmission mechanism as precisely as possible will help identify these other factors and their likely impact on the benefit or cost being evaluated. When critical elements of the project analysis are subject to uncertainty, sensitivity analysis is used to assess the effect of alternate assumptions on the viability of the project.

2.4.3 Classification of Costs and Benefits

The production function and the impact transmission mechanism provide a means to identify the project's physical inputs, intermediate and final physical outputs, impacts attributable to these items, and externalities. Classification of these items as costs or benefits, where a cost is anything that decreases national income and a benefit is anything that increases national income, has to be done next with national income defined as consumption plus changes in wealth.

These costs and benefits may be either tangible or intangible. Tangible costs would include the land, labor, materials, and equipment used for creating or operating the project. Tangible benefits may be in increased production of a good or service, improved quality, change in timing (such as agricultural storage), changes in form (such as exporting instant coffee rather than beans), cost reductions, or losses avoided. Other tangible benefits and costs relate to the economic externalities created by the project, e.g., changes in fishery or agricultural production downstream or changes in health problems associated with polluted air or water. Intangibles by definition cannot be valued, but they can generally be quantified in some form. For example, while there is no reliable way to place a value on having a healthy child, the number of children whose health is improved by the project can be quantified.

2.4.4 Applying With/Without to Obtain Incremental Net Benefits

The proper identification of costs and benefits in project economic analysis requires that the trends and ongoing activities which would exist without the project be considered as well as the changes that occur with the project.

The ultimate objective of applying the with/without concept is the estimation of "incremental net benefits." As the term suggests, it is concerned with the increment to net benefits (total benefits minus total costs) offered by the project over that which would exist without the project. Incremental net benefits are derived by determining the difference between net benefits with the project and net benefits without it. It represents the addition to national income attributable to the project over what would occur without the project.

To properly evaluate the without-project net benefit, the economist must determine whether the project will add to current supply or substitute for existing supply. For the former, the project's output is new supply and, therefore, there is no without-project net benefit to consider. The latter case is more difficult. If the project's output does not change the supply, it is substituting or displacing supply from another source.

If the supply source is imports, then the project's output is evaluated as a traded good and benefits are calculated using the price of the imported good adjusted for any transfers (duties) and distortions in the foreign exchange rate. In this case, calculation of without-project net benefits is not required because production is not within the national economy. If the project's output displaces domestic production, then the without-project net benefits from the displaced production must be estimated and subtracted from the with-project net benefits to arrive at incremental net benefits attributable to the project.

For projects that do not produce an easily defined and valued output, the incremental net benefit calculation is more difficult. In health sector projects such as disease eradication, the with-project benefits are avoidance of costs, i.e., the loss of production from those individuals that become sick or die from the disease. The assessment of project benefits takes this into account when the output of the project is correctly assessed using the impact transmission mechanism, which traces the number of inoculations provided to reduce illness and deaths and, finally, to avoid the loss of production.

When land is used in an agricultural project, it is evaluated according to its opportunity cost, as are all resources used by the project and, therefore, the with/without concept is being applied. The estimation of opportunity cost looks at the best alternative use for the land, which may not be its current use if for some reason the owners of the land are not making productive use of it. An expenditure of project resources to identify and quantify the best alternative use should be in line with the significance of land costs to the project. If land costs are a significant component of total costs then such an expenditure may be justified. If they are not, then it is sufficient to approximate this cost from the use being made of land similar in quality. If the land has

never been cultivated and is essentially unusable for any other purpose, then the without-project net benefits are zero, and the with-project net benefits need not be adjusted.

Care must be taken in applying this criteria to land in a natural, unexploited state. This land may be valuable because of biological diversity or future recreational use. Although it currently produces no marketed product its value is not zero. The economist must seek guidance from those knowledgeable about such matters before assigning a zero opportunity cost to unused land.

In addition, a broader view may be necessary to avoid the "tyranny of small decisions" whereby incremental actions, each of which may have no major impact on a resource, have the cummalative effect of destroying the resource and its production of goods and services. Mangroves, and the related fish and shellfish production derived from and dependent on them, are commonly lost through such actions (Hamilton, 1985).

Different projects will exhibit different problems in the application of with/without. Only through a careful application of the impact transmission mechanism to the project's physical outputs, along with a careful assessment of what will occur with the resources affected by the project over the planning horizon, can the incremental net benefits to the project be correctly estimated.

2.4.5 Double Counting

A problem that often arises when identifying and quantifying costs and benefits is the inclusion of costs or benefits twice. The most common type of double counting occurs in the evaluation of benefits involving externalities. The irrigation project example again provides a clear illustration of this problem. If the increase in land value that results from the increase in crop value brought about by the project is also included as a benefit, then double counting has occurred. This is because the increase in land value is the lump-sum equivalent of the stream of increased earnings from the improved crop yield and, therefore, equal to that direct benefit. Similarly, to include the increase in farm income from the sale of the crops as well as the increased value of the crops as benefits, would be double counting.

A good way to prevent double counting is the careful specification of the impact transmission mechanism. If the impact transmission mechanism is visualized as a chain of events begun by an activity of the project, then, generally, each link in the chain represents an estimate of the economic value of that initial project activity. To include more than one link in the chain would therefore be double counting.

2.5 Financial Versus Economic Analysis

The purpose of financial analysis is to determine the viability of a project from the perspective of the individual participants, using market prices, and including taxes, subsidies, interest payments, depreciation, and other elements of monetary flows. The effects of the project on other individuals (economic units) are not included, which violates the principles of economic analysis. These effects include externalities and the gains and losses in national income from displaced activities.

For example, if a ferry operation is to be replaced by a hovercraft operation, the financial analysis of the hovercraft operation would not consider the cost savings and revenue loss from shutting down the ferry operation, unless the owners of the ferry operation were also the investors for the hovercraft operation. In that case, the financial viability of the investment in the hovercraft operation would be compared against maintaining the ferry operation. Regardless of how the owners or investors are arranged in a project, an economic analysis would include all changes to national income. This requires that the analysis evaluate the revenue loss and resource savings of shutting down the ferry operation against the net benefits of the hovercraft operation.

Although the financial analysis provides a good starting point in identifying the physical inputs and outputs, the economist must use the impact transmission mechanism in a with/without perspective to complete the picture. This requires a careful analysis of the causal chain of events associated with the inputs and outputs in order to identify all impacts on the economy and environment. Following this exercise there are three general steps to follow to convert financial to economic analysis.

The first adjustment is to eliminate the transfer payments, such as taxes, subsidies and tariffs. The second adjustment is the inclusion of externalities. This is necessary to convert the perspective taken in financial analysis of a specific economic entity to the perspective of society in general. The third step is to convert the market prices used in the financial analysis to economic prices employing the concepts of opportunity cost and willingness to pay. Each of these adjustment steps is discussed more fully in the following sections and summarized in Table 2.1.

2.6 Transfer Payments

Transfer payments are eliminated from economic analyses because they do not represent real resource commitments. A tax, for example, reduces the resources available to the taxpayer but increases the resources available to the government by the same amount. Thus, the country is no better or worse off as a result of the transfer and the resource cost of the transfer to the national economy is zero. Other examples of transfer payments are subsidies

and tariffs, and although obvious for many items, they can be hidden in others. Electricity production, for example, is often subsidized by the government, and this subsidy causes electric power costs incurred by a project to understate the true cost to the country.

2.7 Externalities

Financial analyses are concerned with only the impacts of a project which accrue to the economic entity conducting the project. Economic analyses adopt a larger perspective and therefore must include all impacts regardless of where they are felt. Those impacts on others outside of the project boundaries are called externalities. Other terms are commonly used in the literature to depict these effects, such as secondary, or indirect; like externalities, they suffer from a certain imprecision. For example, the distinction between primary and secondary impacts is largely arbitrary. What is important is to ensure that the project activities are examined for impacts outside of the project boundaries.

Some externalities are easier to value than others. Where these impacts can be quantified and valued, it is recommended that they be "internalized" in the economic analysis by considering them as direct costs (or benefits) of the project. Non-quantifiable, non-valued externalities can be included in a qualitative manner. For example, if a proposed project increases water pollution, this will impose a "cost" on downstream users of the water. A fishery may be harmed and the value of this loss of production should be entered as a cost in the project accounts. If the externality cannot be valued readily (e.g. a change in the taste or smell of the water without any associated productivity impacts), then it should be included in a qualitative way in the anlysis. The important point is that externalities should be taken into account and included in the economic analysis in either a quantitative or qualitative manner.

Externalities are generally classified in one of two ways. The most important to project economic analysis are the technological externalities, i.e., those which have a physical impact on society. These would include environmental impacts, such as air or water pollution. Other examples of technological externalities would include the impacts on the water table from

Table 2.1

Summary of Differences Between Financial and Economic Analyses

	Financial	Economic
Step 1		
Transfer Payments (taxes,subsidies,tariffs)	included	excluded
Step 2		
Externalities	Excluded	included
Step 3		
General prices	market price	economic price(based on opportunity costs & willingness to pay)
Foreign exchange	official ex rate*	shadow exchange rate
Labor	wages paid	wages paid for scarce labor; shadow wage rate for abundant labor
Debt Service (principal and interest payments)	included in certain types of fin. analysis	excluded
Discount rate	cost-of-capital rate	opportunity cost of capital

*In some countries, several "official" exchange rates may exist. For example, a commercial rate may be specified separately. The appropriate rate is the one the financial entity actually uses.

tubewell development, increase in disease (e.g., schistosomiasis) from irrigation, or decrease in disease from potable water supply projects.

A second type of externality can occur from the impact a project has on prices in the economy. These are labeled pecuniary externalities and reflect changes in market prices caused by a project which cannot help but alter the resource allocations within the economic system. Tracing the economic impact of these changes is extremely difficult, however, and generally should not be attempted unless the impacts are quite obvious. An example of such an obvious pecuniary externality is the change in consumer surplus generated by a decrease in the price of a project's product as a result of the increased supply provided by the project. Other resulting price changes are normally assumed to be more in the nature of transfer payments and therefore excluded from the analysis.

International price effects would include such things as the impact of changes in international prices on nations which trade in the commodity produced by the project. Although these impacts are not included in project economic analysis, decision-makers should be aware of the existence of such effects. An exception to this is when projects actually span geopolitical borders. In this case, the analysis is generally carried out on both the country level (excluding international effects) and on the project level for all countries, which would include international effects for those countries participating in the project.

Another type of externality is known as the multiplier effect. Multiplier effects are the ultimate increase in national income and employment stimulated by the project activities. These effects, while commonly included in project analyses in developed economies, are generally not valid in project economic analysis in developing economies for two basic reasons. The first is that the project economic analysis use of shadow prices incorporates much of the same effects captured in multiplier analysis. Thus, to include multiplier effects in addition to using shadow prices would result in substantial double counting. Second, the multiplier effects would affect all project alternatives in an equal fashion, thus not affecting rankings. The superior alternative would be chosen regardless of the inclusion of multiplier effects. In addition to these problems, the multiplier effects can be difficult and time consuming to estimate.

2.7.1 Environmental and Resource Effects

Environmental and resource effects of projects should be included in the economic analysis as part of the standard analysis of projects and not as "environmental add-ons." We must consider these effects now and take required actions and appropriate measures, or we can ignore them and pay the costs later. The

general steps involved for taking environmental effects into account are the same as for direct project outputs--identification, quantification or measurement, and valuation. The same type of impact-transmission mechanism discussed earlier can be used to trace the impact of environmental effects. Identification and measurement steps require the collaboration of social and natural scientists. The economist cannot do it alone.

A major question is deciding where to begin and where to end the analysis of environmental effects. By their very nature, environmental effects are wide ranging and, if carried to their ultimate level, the cause-and-effect relationships become so tenuous that it is improper to carry the analysis too far. For example, deforestation and resulting soil erosion and sediment can have effects on a nearby stream, a downstream reservoir, a coastal ecosystem, and a major bay, guilf, or sea. One project, a logging operation for example, may cause soil erosion that ultimately effects all of these different parts of the environment. Our level of certainty on cause-and-effect relationships, however, rapidly decreases with distance from the project site.

The hardest task is to decide which environmental or resource impacts to include and how to quantify and value them. A useful approach is one that requires the analyst to "think-through" each problem, make decisions and identify guidelines that should be of help in setting up the analysis (the rest of this section draws heavily on Dixon et al., 1986):

1. Start simply with the most obvious, most easily valued environmental impacts. This may mean looking for impacts that result in productivity changes and that can be valued using market prices. A mining operation, for example, may disrupt a traditional downstream fishery or agricultural activity. The new change in fish or crop production can be identified and valued (and may already be done as part of the project analysis). The change in downstream water quantity or quality and its effect on a mangrove area or an offshore reef system is a second-order effect. These latter effects may be very important, both ecologically and economically, but the analyst would do best to start with the fishery or agricultural component first. In sum, start with effects that have directly productivity changes and that can be valued using market prices.

2. There is useful symmetry in benefits and costs: a benefit foregone is a cost just as much as a cost avoided is a benefit. The analyst should always look at both the benefit and cost sides of any action, and approach valuation in the most feasible and cost-effective way. The value of improved industrial wastewater treatment should be approached from both the direct cost side (largely engineering and OM&R costs) and the "costs avoided" side - i.e., the benefits of reduced downstream water purification costs or reduced morbidity. The distinction between benefits (costs avoided) and costs is the reference point from which changes are measured. If a decision is made to achieve pollution control, even though benefits are not measured, the approach is a form of cost-effectiveness analysis discussed in the Appendix.

3. The economic analysis should be done in a with-and-without project framework. A series of alternative "with project" options (e.g., varying scale) may need to be considered and thereby compare the overall impact of different packages of technologies, project outputs, and environmental impacts.

4. When market prices cannot be used directly, it may be possible to use them indirectly by means of surrogate-market techniques. In these approaches, the market prices of substitute or complementary goods are used to value an unpriced environmental good or service. For example, the value of an unpriced environmental amenity, such as clean air, may be a factor in the price of marketable assets, such as housing or land. Analysis of the price differentials of such assets in areas of varying air quality may give an indication of an implicit price for the unpriced environmental amenity.

The choice of a particular measurement approach will obviously depend on what effect is being measured. Although a wide range of measurement/valuation techniques have been developed by economists, this section will introduce those techniques that are considered to be generally applicable to a wide range of common environmental effects.

Table 2.2 lists the techniques. The first set, those considered to be generally applicable, are fairly standard, straight-forward approaches that largely rely on changes in physical production, or direct cash expenditures (e.g., preventive expenditure, cost-efectiveness). Opportunity cost and loss of earning approaches look at economic costs associated with environmental impacts. These approaches provide powerful tools for measuring many environmental impacts.

The second set of approaches are labeled as "potentially applicable" because they can be used only in certain situations. These approaches are usually more indirect and rely on either surrogate markets (e.g., travel cost, property value, land value approaches) or the costs involved with relocating or replacing facilities. The scope for using both sets of techniques is elaborated in the test.

A brief overview of a number of these techniques follows. A fuller overview is presented in the Asian Development Bank report "Economic Analysis of the Environmental Impacts of Development Projects" (Dixon et al. 1986); detailed presentations on various economic valuation techniques can also be found in Sinden and Worrell (1979), Hufschmidt et al. (1983), and Dixon and Hufschmidt (1986).

2.7.1.1 Generally Applicable Techniques. All of the techniques presented here use market prices to determine values. As such the implicit assumption is that these prices reflect economic scarcity and are therefore economic efficiency prices. If distortions exist in the market prices appropirate adjustments will be required.

1. Techniques in which Market Prices are Used to Value a Change in Production

Three sets of techniques are considered. Each set uses market prices to value a change in production of some good or service. The first set deals with changes in productivity and the value of output; the second, with loss of earnings; and the third, with the opportunity costs of different actions.

(i) Changes in Productivity Approaches

Changes in productivity approaches are direct extensions of traditional benefit-cost analyses. Physical changes in production are valued using market prices for inputs and outputs (or, when distortions exist, appropriately modified market prices). The monetary values derived are in turn incorporated into the economic analysis of the project. Benefits and costs of an action are counted regardless of where they occur -- within the project boundaries or off-site.

Table 2.2

Measurement and Valuation Techniques

Generally Applicable

1. Those that use the market value of directly related goods and services:

(i) Changes in productivity approaches

(ii) Loss of earnings approaches

(iii) Opportunity-cost approach

2. Those that use the value of direct expenditures

(i) Cost-effectiveness analysis

(ii) Preventive expenditures

Potentially Applicable

1. Those that use surrogate-market values:

(i) Property value approach

(ii) Other land value approaches

(iii) Travel-cost approach

2. Those that use the magnitude of potential expenditures:

(i) Replacement costs

(ii) Relocation costs

Productivity effects should be monitored and measured in a with- and without-project context. Even if alternative projects are being considered, the "without-project" option should be retained. The reason for this is simple -- we have to be able to specify the change due to the project given the existing situation. For example, an agrilcultural development project in an upland area generates soil erosion and downstream damage to irrigated rice fields. The environmental "cost" of the project is not the total damage in the downstream fields, but only that additional sediment load due to the project. The with- and without project analysis will help clarify the additional erosion created by the project.

This technique is commonly used because it presents the fewest measurement and valuation problems, especially when the cause-and-effect relationship is direct and clearly seen. Water pollution by a factory and resulting fish kills is an example. Mangrove destruction and decreased near-shore fish catch is another.

(ii) Loss of Earning Approach

The loss of earnings approach is similar to the change in productivity approach. In this case, the productivity of human beings is used as a measure of environmental impacts by examining lost earnings and medical costs from an instance of environmental damage or the benefits from preventing the negative environmental impact. Also known as the human capital or foregone earnings approach, these techniques present some major ethical problems when human life itself is valued. Some of these issues are discussed in Section 4.3 of this manual.

Some general guidelines for choosing projects for which the loss of earnings approach can be used include the following:

- A direct cause-and-effect relationship can be established. The etiology of the disease should be clearly identifiable.

- The illness should be of short duration, non-life threatening, and have no major, long-run effects.

- The precise economic value of earnings and medical care costs should be known. For example, unemployed laborers or subsistence farmers present valuation problems.

Certain types of environmentally related diseases are very difficult to assess. Consequently, great caution must be taken in using the loss of earnings approach to evaluate projects where the etiology is not well established (e.g., mortality and level of sulfate emissions) or a large number of pollutant sources make cause-and-effect relationships difficult to pinpoint. If the

disease is chronic or the effects are debilitating but do not prevent all work, the valuation problem becomes complicated by measurement issues. This is the case when a person functions at less than full potential although being seemingly "healthy." Malnourishment and chronic parasite infections commonly produce such effects.

(iii) Opportunity-Cost Approach

The opportunity-cost approach is based on the concept that the opportunity cost of unpriced or unmarketed uses of resources (e.g., preserving land for a national park instead of cutting the trees for timber) can be estimated by using the foregone income from other uses of the same resource as a proxy. As such, the approach measures what has to be given up for the sake of preservation; it does not measure the benefits of land preserved for other (often unpriced) uses. The opportunity-cost approach is therefore a measure of the "cost of preservation"; this information is in turn used to evaluate the options available to a decision maker. In many cases the "cost of preservation" has been found to be low and has resulted in decisions to conserve or preserve.

A famous example of the use of this approach is the Hells Canyon study in the United States (Krutilla 1969, Krutilla and Fisher 1975). In this case, the proposed damming of Hells Canyon for hydropower generation would have irrevocably altered a unique wilderness area. Rather than attempt to value the canyon in its natural state, the analysts undertook conventional benefit-cost analyses of both the proposed hydropower project and the next cheapest alternative. The analysis also included the benefits from reduced flood damage if the dame were built. Sensitivity analysis was done on various parameters and, when the results were presented to the decision makers, they decided not to build the dam. The opportunity of preservation -- the additional expense of generating power from the alternative source -- was judged to be worth paying in order to preserve Hells Canyon.

The development of new seaports, airports or highways frequently requires use of open, undeveloped or sparsely developed areas. In cases where alternative locations exist, the opportunity cost approach helps clarify the additional cost of preservation.

Similarly, decisions on choice of technology also frequently involve environmental impacts as well as more narrow economic criteria. Cooling ponds or cooling towers for heated water, overhead or underground utilities, a parking lot or a parking structure -- these are all examples where options exist between alternative ways of meeting the same need. The opportunity cost approach can be used to quantify how much more we would have to pay to choose an environmentally preferred, but more expensive,

alternative. The opportunity cost approach is a powerful tool in illustrating the real cost differences between two or more alternatives which may have very different environmental impacts.

2. Techniques in Which Market Prices are Used to Value Costs

Two additional sets of techniques rely on the use of market prices to estimate the costs that are actually incurred. The first approach, cost-effectiveness analysis, is a widely used economic and engineering tecnique. Preventive expenditure approaches, the second approach, also examine direct costs involved with certain actions. For both approaches the analyst must determine that the potential benefits justify the costs involved.

(i) Cost-effectiveness Analysis

Due to limited funds, lack of data or insufficient knowledge concerning the link between environmental damage and human health and welfare, it may sometimes be more useful to first set a goal and then analyze different means of achieving it. Conversely, if there is a level of funding available for a certain program and the policy maker must decide which method of utilizing the funds will be most effective. Alternatively, one might consider a number of goals, examine the difference in cost of achieving them, and then decide which goal seems most reasonable considering the cost involved. All of these methods are types of cost-effectiveness analysis. The major difference between cost-effectiveness and other approaches is that no attempt is made to measure benefits in the former approach. Rather, the focus is entirely on meeting a set of predetermined standards or goals. This technique is discussed at length in the Appendix.

(ii) Preventive Expenditures

Estimates of individuals' minimal valuations of environmental quality can sometimes be estimated from their willingness to incur costs for mitigating or preventing adverse impacts to themselves or the environment. This approach is known as the "preventive expenditures" or "mitigation expenditures" method. The approach gives a minimum estimate because of two factors: actual expenditures may be constrained by income, and there may be an additional amount of consumer's surplus, even after the preventive expenditure has been made.

An example of the use of the preventive expenditure approach would be for an urban water supply project. The preventive expenditure approach would examine how much people pay now to obtain drinking water from alternative sources in order not to be exposed to pathogens. Alternative water sources include door-to-door sales, private wells and filtration systems, boiling of water supplies and even bottled water. The alternative chosen depends in part on

income and hence ability to pay, but gives a realistic picture of the willingness to pay by various groups of consumers for potable water.

A similar type of analysis can be done for other public services such as electricity or trash collection. In each case, the analyst should examine how the goods or services that will be provided by the project are presently being provided.

2.7.1.2 Potentially Applicable Techniques. This section presents a series of approaches and techniques that also have been used to place values on environmental impacts. These techniques are termed "potentially applicable" because they either require greater care in their use, make more demands on data or other resources, or require stronger assumptions than the more directly operational techniques presented in Section 2.7.1.1.

As indicated in Table 2.2, the techniques presented here fall into two broad categories: those that use surrogate markets to determine values, and those classified as cost-analysis techniques which assess the magnitude of potential expenditures.

1. Techniques in Which Surrogate Market Prices Are Used

Many environmental effects have no established market prices. Clean air, unobstructed views, pleasant surroundings are all goods or services that have some public good characteristics. As such, established markets for the goods have not developed. In many cases, however, value of an environmental good or service can be estimated by means of the price paid for another, marketed good.

Surrogate market techniques, therefore, offer approaches that use and observable market price to value an unmarketed environmental impact. The basic assumption is that the observed price reflects the purchaser's total valuation of a good or service. The valuation includes both tangible, easily priced components as well as less tangible environmetal attribute.

(i) Property Value Approach

The property value approach is a prime example of the surrogate market approach. The basic assumption is that consumers will reveal their attitude to a bundle of attributes by their willingness to pay for a piece of real estate. This approach is commonly applied to residental properties such as houses or condominium apartments. If there were no values placed on environmental or other nonmarketed attributes one would expect the value of a house to be equal to its construction cost plus an appropriate mark-up. In reality, of course, house values reflect a very large range of attributes, only some of which are physical. The property value approach is designed to control for certain

variables in order to estimate a value for other, frequently unpriced environmental variables. As usually applied, the property value approach requires extensive data on selling prices of individual units and a host of physical characteristics. Most of the variables are easily measured, such as number of rooms, floor space, construction materials and so forth.

(ii) Other Land Value Approaches

Other land value approaches are based on the same principles as the property value approach. This set of approaches uses an observable market price (usually retail land price) to evaluate a combination of impacts. If the prices of neraby pieces of land are determined, for example, any difference between parcels will normall be due to one of two factors: productivity effects, or unpriced environmental impacts. Productivity effects can be measured using the change in value of output approach described earlier. The capitalized value of the productivity of land should be reflected in its retail price. In addition, there may be other unpriced impacts that are also incorporated in land value. These could include such things as aesthetic values, decreased risk of flooding or other environmental catastrophe (although this should be captured in the productivity analysis), or increased attractiveness as a wildlife habitat.

(iii) Wage Differential Approach

The wage differential approach is similar to the property value approach. It rests on the theory that in a perfectly competitive equilibrium, the demand for labor equals the value of the marginal product of the workers, and that the supply of labor varies with working and living conditions in the area in addition to the wage rate. A higher wage is therfore necessary to induce workers to locate in polluted areas or to undertake risky occupations. Workers are supposedly able to move freely among jobs and are therefore able to choose a particular job in a particular area at a certain wage that will maximize their utility. Unless wages are systematically varied to achieve equilibrium in the labor market and laborers have freedom of movement, this approach cannot be used.

(iv) Travel Cost Approach

The travel cost approach has been extensively used in developed countries to examine and value recreational goods. Developed in the late 1950s and 1960s (Clawson 1959; Clawson and Knetsch 1966), this approach is based on the simple proposition that observed behavior can be used to derive a demand curve and estimate a value (largely consumer's surplus) for an unpriced environmental good by treating increasing travel costs as a surrogate for variable admission prices.

Although use of the travel cost approach initially would not appear to be applicable with most A.I.D. projects, the technique can often be used to place value on a component of a larger project. A dam/reservoir project, for example, may result in the creation of a new recreational facility for boating, swimming and sports fishing. A travel cost approach could place a value on the recreational uses. Cultural or historical sites could also be analyzed by using this approach. In such cases the value obtained should be clearly identified as a minimum valuation of only part of the total value of the resource.

2. Cost Analysis Techniques

The cost-effectiveness analysis, preventive expenditures and opportunity cost approaches were included in the "generally applicable" section because they relied on the measurement of actual expenditures using market prices. Here, we present two additonal cost analysis techniques that rely on information on potential expenditures to value an environomental impact. Each approach examines the costs that would be involved if a potential environmental impact were mitigated by replacing the environmental services destroyed or damaged. This information is then used to determine if it is economically more efficient to take preventive measures or to take compensating measures after some damage has occurred.

Both techniques are similar; they are presented separately, however, because there are certain situations where one technique will be more directly applicable than the other.

(i) Replacement Costs

The basic premise of the replacement cost approach is that the costs incurred to replace productive assets which are damaged by a project can be measured, and these costs can be interpreted as an estimate of the presumed benefits of measures to prevent that damage from occurring. The rational for this approach is similar to that for preventive expenditures except that the replacements costs are not a subjective valuation of the potential damages, but rather, are the actual costs of replacement if damage has occurred. As such, the approach can be interpreted as an "accounting procedure" that examines if it is more efficient to let damage occur and repair it or to prevent the damage from occurring. This approach gives an upper-bound estimate but does not fully measure the benefits of environmental protection, per se.

(ii) Relocation Costs

The relocation cost approach is a variant of the replacement cost technique. In this case the actual costs of relocating a physical facility because of changed environmental quality are used to evaluate the potential benefits (and associated costs) of preventing the environmental change. For example, the construction of an oil palm mill will result in wastewater discharges into a nearby stream. Of the various environmental costs associated with this discharge one might be the need to relocate a domestic water supply intake which is currently located downstream. If the intake is not relocated, but additional treatment equipment is installed, this becomes an example of a preventive expenditure.

2.8 Economic Prices

The estimation of economic prices is one of the most important elements of project economic analysis as well as one of the most difficult. Conceptually, economic prices are derived by implementing two basic principles -- opportunity cost and willingness to pay. Resources consumed by the project are valued according to their opportunity cost, which requires estimating the best alternative use for the resources. The best alternative use is measured by what society will have to give up when using the resource in the project. If the market for the resource is competitive, then the price may accurately reflect its opportunity cost. But in developing countries, economic conditions, social factors, and macroeconomic policies often cause a divergence between the supply price and the opportunity cost.

The second concept employed in deriving economic prices is the valuation of a project's output according to society's willingness to pay as contrasted with what the consumers of the output actually pay. Divergences between market price and willingness to pay (WTP) can occur for many reasons, such as subsidies and taxes which distort market structures. There can also be a divergence between an individual's willingness to pay and society's willingness to pay. As project economic analysis is concerned with the societal perspective, it is society's willingness to pay which must be estimated. The most common case of divergence between society's and an individual's willingness to pay is that of the merit good. In this case, individual consumption confers benefits to society in excess of the benefits accruing to the individual consumer. An example of a merit good would be inoculations against communicable diseases. An individual protects him/herself by "consuming" an inoculation and, simultaneously, protects those potentially infected by that person if not inoculated. (It should not be forgotten that willingness to pay, when measured by actual expenditures, is restricted by an

individual's ability to pay. Therefore the strict use of measured WTP might show a poor person placing a much lower "value" on the same health care product or service than a rich person would. Obviously there are problems with using WTP measures).

A concept which derives from the willingness to pay criteria is that of consumer and producer surplus. An increase in consumer surplus arises when the price of the output of the project falls as a result of the increased supply of outputs. Because the new, lower price is paid by all consumers, those previously consuming the product at the higher, pre-project price, will reap the benefit of the lower price. This increased benefit is called consumer surplus.

All economic prices are estimated at the project's boundary. That is, inputs are priced as delivered to the project and outputs are priced at their point of departure from the project. In agricultural projects this would usually be the farm gate and for industrial projects, the plant gate. Also, all prices are expressed in domestic currency. The opportunity cost and willingness to pay principles are applied in project economic analysis as discussed in the following subsections. Because the estimation of economic prices is very different for traded and nontraded goods, they are discussed separately.

2.8.1 Defining Traded and Nontraded

A distinction is made between "traded" and "nontraded" goods and services because of a need, in most cases, to correct for a distortion in the value a country places on its currency (the foreign exchange rate). For most goods and services, the distinction between traded and nontraded is obvious. When the country exports or imports goods and services these items are considered to be traded, when they are not they are usually considered to be nontraded (produced and consumed domestically). This distinction is complicated by the fact that some nontraded items may be "tradeable." In this case, a world market exists for the item but the country in question does not export or import the item.

This situation can arise when the government restricts imports with high tariffs to protect domestic industry (the "infant industry" argument), or when exports are banned on a staple food item to keep prices low (below world prices). Therefore, when goods are tradeable but not traded, the option to import or export still exists. Applying the opportunity-cost principle to the case of restricted imports, leads to the use of a world price; the next best alternative use of the domestic resources used to produce the item. Applying the willingness-to-pay principle to the restricted export case also leads to the use of a world price; consumers would have bid the price of the product up to its world price level in the absence of restrictions.

There is a caveat to treating nontraded but tradeable items as "traded." The difficulty occurs when a world price is available for a product, but it is still uneconomical to import (export) the item to (from) the country because of excessive transportation costs. The economist must work back from the port of border (the source of the so-called border price) and include transportation and handling charges to see whether or not the good is actually tradeable where it is produced. In many remote locations it will not be. Therefore, the item is not tradeable to the country in question. In general, a good is nontradeable if the difference between the world market and domestic market prices is less than the transportation costs, i.e., the sum of international and domestic transportation costs including freight insurance and handling charges. The economist must evaluate each project's inputs and outputs carefully to determine their status as traded or nontraded.

Another difficult situation exists when inputs used by the project are produced domestically and contain a significant amount of traded components. In this case, the traded and nontraded components should be separated as best as possible so that economic prices can be calculated for each component.

2.8.2 Economic Prices of Traded Goods

Goods and services traded internationally are separated from domestic goods and services because of distortions due to tariffs, subsidies, trade restrictions, and foreign exchange policies in developing countries. These distortions result in over or under valued currencies. Therefore, the foreign components of all inputs and outputs of a project must be adjusted to correct for these distortions.

2.8.2.1 The Shadow Exchange Rate. The shadow exchange rate (SER) is used in project economic analysis to correct for distortions in the market for foreign currency. Typically, these distortions cause the domestic currency to be overvalued so that the actual value of the foreign component of each traded item exceeds that calculated using the official exchange rate (OER). The reasons for these distortions are numerous and varied. They exist in virtually every developing country but in different degrees from one country to another.

At the core, the distortions arise from the developing nations' efforts to reduce the destabilizing effects of large fluctuations in the value of their currency. Because their currencies are not freely convertible, purchases of imported items must be made with foreign currency earned or borrowed. When demand for imported items is high, and foreign exchange earnings are low, the domestic currency value would naturally fall introducing

inflationary pressures, and increasing the level of uncertainty in the economy, which can lead to hoarding and black market activities. Other motivations include favoring the use of foreign currency for investment in imported equipment, rather than for luxury consumption, and the policy for the government to maintain the value of domestic currency.

When trade is not balanced, the nation must borrow foreign currency and runs the risk of debt problems which can result in unwanted foreign interventions on their domestic economy. The ways in which trade may be kept in balance (given that devaluation is restricted) include tariffs on imports, subsidies on exports, quantitative restrictions on imports either through quotas or licensing, and foreign exchange movement controls. Tariffs on exports are also common even though they serve to worsen trade balances. They are used as revenue sources which are politically more acceptable, especially if the exporter is foreign.

All of these controls serve to create a disequilibrium in the supply and demand for foreign exchange. This results in the demand price exceeding the supply price with the official exchange rate generally closer to the supply price. The real cost of imports to the economy or the real benefits of exports associated with a project would, however, be measured by the demand price. The SER does not, however, reflect the exchange rate that would exist if the foreign exchange market was in equilibrium. Rather, it is the demand price associated with the disequilibrium condition.

As a first approximation of the SER, the economist can investigate the "black" or "gray" markets in foreign exchange. Buyers in this market will spend more than the official rate to purchase foreign exchange, thus they provide an indication of the premium to attach. The drawback to these markets is that they are illegal (gray markets are not necessarily illegal, but governments severely restrict the flow of foreign exchange through the financial institutions) and therefore, questionable sources for data-gathering activities and, in some instances, tend to be thin and volatile. The illegality of the black market affects the foreign exchange premium by attaching a "risk" premium to it, which is unobservable and therefore indeterminable. This distortion may be substantial and therefore may result in a significant overestimation of the SER, when black market rates are used.

Alternatively, the SER can be estimated from readily available aggregate trade statistics (UNIDO 1978, pp. 215-216 and Kitchen, 1985, pp. 56-58). This method represents a reasonable "second-best" method for incorporating the effects of scarce foreign exchange. However, this is not a precise approach and should be

combined with other observations to develop a range that can be used in sensitivity analysis. The approximation of the SER using trade statistics is:

$$SER = \frac{(M + Tm) + (X + Sx)}{M + X} OER \qquad (1)$$

where:

SER = Shadow exchange rate

OER = Official exchange rate

M = Imports

Tm = Taxes on imports

X = Exports

Sx = Export subsidies (export taxes would be treated as negative subsidies)

(NOTE: all values are in domestic currency)

Equation 1 assumes that the marginal unit of foreign exchange affects imports and exports in the same proportions. If a country has a high marginal propensity to import, a better formula is equation 2:

$$SER = \frac{M + Tm}{M} OER \qquad (2)$$

Conversely, if a high marginal propensity to export is evident, the appropriate formula is equation 3:

$$SER = \frac{X + Sx}{X} OER \qquad (3)$$

Each of these equations can be divided by the official exchange rate (OER) to provide a ratio of SER to OER. It is this ratio that is usually applied to the foreign exchange components which have already been multiplied by the OER to put them in local currency terms.

There are two important limitations of these formulas. First, they are unable to incorporate common nontariff controls (e.g., quotas or outright bans on imports). Second, they consider the import/export tariff and subsidy patterns to reflect only trade control aspects of macroeconomic policies. If tariffs or subsidies are used by the government for generating revenues, then these formulas will not provide accurate measures of the distortions in the foreign exchange markets.

Three common situations can bias the trade-based methods of estimating the SER. The first two relate to the government's use of tariffs as sources of revenue, rather than for balancing trade, and the third relates to quantitative restrictions.

The first situation occurs when tariffs on imports are used as revenue sources. This results in an increase in Tm more than the amount needed to balance the trade which biases the estimate of the SER upward. The second situation applies when tariffs are levied on exports for revenue generation. This results in a downward bias in the SER. The third situation occurs when restrictions are imposed on the quantity of imports through quotas or licensing. These non-tariff methods would not be reflected in Tm and would, therefore, bias the SER estimate downward. Because a higher tariff on imports would be required to achieve the effect of the non-tariff measure, the effect of these measures is to under-estimate the true value of Tm.

In practice, there is no reliable way to quantify biases resulting from these three conditions. Combining estimates from trade-based data and observations on the informal currency markets with the knowledge of the direction and likely magnitude of biases, can, however, provide the economist with a range of estimates for the SER. The final value must then be judgmentally derived. It is also good practice to test the sensitivity of the project's economic viability to the SER using the range of estimates derived.

2.8.2.2 Mechanics of Pricing Traded Goods. The development of economic prices for traded items used or provided by the project will depend on which of five situations arise. Does the project:

1. produce an item which will be exported?

2. use an item which would have been exported without the project (diverted exports)?

3. produce an item which would have been imported without the project (import substitutes)?

4. use an item which would not have been imported without the project?

5. use or produce items which are not traded but are tradeable?

The development of the economic price of traded items in each of these cases is made more complicated by the presence of transportation, insurance, and handling charges. The most straight-forward method is to divide the process into two steps. The first isolates the foreign exchange component by establishing the price at the nation's border (border price) to which the SER is applied. The second step is to calculate the price at the project boundary. In the diverted export and import substitution situations, transportation and marketing costs must be estimated with and without the project to determine if any domestic cost savings or losses result.

When the project will produce an export, or will divert an export, the border price is the free-on-board (f.o.b.) price which includes the costs of transporting the good to the port and loading it, but does not include the insurance or transport fee to its destination port. The f.o.b. price therefore represents the foreign exchange component. The f.o.b. price, multiplied by the SER, provides the economist with the economic value of the good at the nation's border. The adjustment needed to arrive at the price at the project's boundary, in the case of increasing exports, is simply the subtraction of transport costs from the project site to the port. In the case of diverted exports, the economist must also consider whether any transportation costs are saved by not exporting the good.

When the project will use an import, or will produce an import substitute, the appropriate border price is the cost-insurance-freight (c.i.f.) price which includes all costs necessary to get the import to the dock of the importing country. After applying the SER, the price is, as before, adjusted to reflect the value at the project boundary. Any domestic transportation costs incurred to get the good to the project site would be added; any domestic transportation costs saved through import substitution would be deducted. A discussion of the mechanics of calculating import and export parity prices is provided in Chapter 3, Sections 3.5.2.1 and 3.5.2.2. Developing nations are generally price-takers in their export markets, therefore, it is rare for project activities to cause a fall in world prices.

However, when project activities will cause a change in the price for a traded item, it is important to use marginal earnings. For example, if exports are increased but the price is expected to fall, the country will receive that price for all of its exports of the item including those produced by the project.

2.8.3 Economic Prices of Nontraded Goods

The first approximation of economic price for a nontraded good is the market price. If the good is an output and is traded in a reasonably competitive market, then market price will reflect the society's willingness to pay. If, however, the market price is expected to change as a result of the project's additional output, then the benefits must be valued according to the consumer surplus generated by the project. The increased consumer surplus can be approximated as the quantity of total production multiplied by the change in the maket price. Predicting with-project price changes can be quite difficult, which diminishes the usefulness of the consumer surplus concept in practice. If the good is an input and is being purchased from a reasonably competitive market, and if no significant price change is caused by the project, and no excess capacity exists in the industry, then the market price is a good measure of the opportunity cost. Treatment can be found in Sugden and Williams (1978, pp. 113-122).

Labor and land are two nontraded items which in many projects require special attention. Unskilled or abundant labor is treated separately from skilled labor because of disparities in the opportunity cost of unskilled labor and the actual wage. Land can be difficult to value because of the practical problems inherent in determining its opportunity cost. Because of such factors these two nontraded items will receive more attention.

2.8.3.1 The Shadow Wage Rate for Labor. The literature on the definition and calculation of the shadow wage rate (SWR) has developed from a number of theoretical foundations. Not all of these approaches are helpful to the economist confronted with the realities of project analysis. Namely, the problems encountered with data sources and the complexities of individual cases make estimation of the true opportunity cost of labor a difficult task. The approach taken in this manual will relate closely to the practicalities of estimation from limited data as discussed in Gittinger (1982, pp. 258-263). Other discussions of the SWR can be found in UNIDO (1972, pp. 201-212), Little and Mirrlees (1924, pp. 157-180), and Squire and van der Tak (1975, pp. 78-87).

Before attempting to estimate the SWR, the economist should make every effort to ascertain what estimates government planning agencies have made of the SWR. Limitations found with planning agency numbers will be instructive on just how much the economist himself can do for the project at hand. Unless the project can spend the resources to gather regional, seasonal, and skill-level data on the labor pool to be affected by the project, the economist probably cannot do any better than planning agency estimates.

In many developing countries, wages are set administratively for each skill class, therefore, the project wage paid to skilled and unskilled labor is predetermined. In general, unskilled labor supply is abundant and the administratively set wage rate for this labor class probably does not accurately reflect the opportunity cost to society of moving labor from its without-project occupation to its with-project job. This is because, in a situation with abundant labor, the marginal worker does not contribute much to production -- his marginal value product is relatively low.

In agricultural areas (rural) with surplus labor, one more laborer will add little to aggregate agricultural production. If the project taps this labor pool, then the wage rate offered by the project will likely be higher than the value the worker previously added to agricultural production. If the project hires this worker during the peak labor season (usually harvesting), then the wage rate may be very close to the marginal value product of the worker because nearly all workers can find employment during the peak season. This is the seasonality factor that should be considered in estimating the SWR.

The marginal value product of labor may also differ regionally if the labor pool differs in composition and degree of abundance (oversupply). If possible it is best to use data from the specific region where the project will be hiring unskilled labor. Again, if this proves difficult to obtain, estimates from other regions must be used.

In most studies, the productivity of the marginal agricultural worker, what we call the "rural" wage, is used to determine the shadow wage for a project. This is true for industrial projects in urban areas as well as rural agricultural projects because the workers drawn from the unemployed urban labor pool will be replaced by rural workers -- only the output of the rural worker is lost. Because home production of consumption goods is an important source of income in developing countries, some estimation of the value of this labor should be included in the rural wage calculation.

2.8.3.2 Land. Land is valued according to its opportunity cost which is equal to the net value of forgone production by implementing the project. In the simplest case, the land's use is not much changed and the with-without approach to evaluating benefits would incorporate the change in the opportunity cost of the land. For example, a rice farmer provided with a new, higher-yielding species in an agricultural project would count only the increased production as a benefit. This is equivalent to

considering the total production as a gross benefit and subtracting the prior production to reflect the land value without the project. If benefits have been accurately assessed in this type of project, the opportunity cost of the land has already been accounted for.

For nonagricultural projects, the value of land is also determined by its opportunity cost, but usually there are good market indicators to reflect this value, such as purchase price or rental rates. If land is a large component of the project, then it is recommended that the economist verify the accuracy of the market price as a reflection of opportunity costs and, further, that this opportunity cost be entered into the project accounts as an annual rental rate rather than a lump-sum purchase price. This is because a lump-sum purchase price implicitly incorporates a discount rate in converting the perpetual stream of opportunity costs to present value via the relationship:

$$V = R/i \tag{4}$$

where:

V = value of land

R = rental rate

i = discount rate

If the discount rate implicit in the value of land is substantially different from the economic internal rate of return (discussed in a later section), then the results will be biased. The terminal value of the land will always contain an implicit discount rate whether or not land is valued in terms of an annual rental rate. With industrial projects, land is usually a small fraction of investment costs and, therefore, its valuation is of less concern. Note that this approach to valuing land may or may not include unpriced values from environmental services. If these have not been included, the value determined and the opportunity cost of the land will be underestimated. For example, a forest area may be used for both logging and recreation. If V, the value of land, is calculated solely on the rental rate charged by government to a logging firm, the calculated V will be too low. An additional value for recreational use should also be included, provided that they are not mutually exclusive.

2.9 Other Aspects of Project Economic Analysis

The application of the principles discussed above in adjusting traded and nontraded goods would provide the economist with the economic prices needed to conduct the project analysis. Several areas still remain which are not easily categorized as explained below.

2.9.1 Discount Rate

The discount rate is used to equate future costs or benefits with their present values; having a benefit today is intrinsically better than having it years from now. It is the discount rate which reveals how much better. While the generally recognized appropriate rate for use in financial analyses is the cost of capital rate, economic analyses use the opportunity cost of capital (OCC). Much has been written on the advantages and disadvantages of various definitions of the OCC to be used in project economic analysis, but no clear answer has emerged. Since the OCC is not readily observable in the economy, the actual rate to be used in the economic analysis will be country specific and will probably be established as a matter of government (or A.I.D.) policy. The analyst, therefore, should seek guidance from responsible government policy-making agencies on the discount rate to be used. In the absence of such guidance, the economist should analyze the project using a range of rates reflecting those currently in use in the country for public investment projects. It should also be remembered that for an economic analysis the discount rate does not reflect inflation; all prices used in the analysis are in real or constant prices. The interested reader could find a good summary of the controversies involved in Irvin (1978, pp. 127-132). Other important references would include Baumol (1968), Dixon and Hufschmidt (1986), and Marglin (1967).

2.9.2 Sunk Costs

These costs are those which have been incurred prior to project appraisal and cannot be avoided. In other words, these costs would not change with or without the project. Following the logic of with/without would therefore lead to the exclusion of such costs. The exception to this rule would be if there were some alternative uses for the item produced by the sunk cost; in this case, the opportunity cost principle would indicate the value in the best alternative use would be the proper one to include in the project regardless of the cost of producing the item. For example, if an existing well is proposed for use in an irrigation project, then its economic cost would be zero if there were no alternative use for the well. If a neighboring village could use the well for domestic water supply, then its economic cost would be represented by the well's value to the village.

2.9.3 Contingencies

Financial analyses often contain contingency allowances for possible changes in the base cost estimates of the project. The economist needs to be aware of these components of the financial analysis because of pricing considerations. For example, if

contingency allowances have foreign as well as domestic components, the economist must be sure to separate them for application of the SER to the foreign component.

Such allowances are made for physical contingencies where problems may arise over the life of the project requiring more inputs to meet projected targets. Physical contingencies are usually associated with civil works projects, where excavation, land clearing, or construction is required. In these cases, problems may arise relating to terrain conditions that turn out to be different than initially expected. For example, if land is to be cleared in an agricultural project, and tractors are to be used for this task, problems with the terrain may result in a need for more tractors to perform the land preparation task than was assumed in the base cost estimates. Physical contingencies are economic costs in project analysis.

Price contingencies are another kind of allowance included in financial analyses and can be divided into two types. The first is to reflect expected changes in relative prices, such as a decrease in electric power costs expected as a result of geothermal generation plant completions. These also are a valid part of economic analysis. The second type of price contingency is to incorporate expected changes in the general price level, i.e., inflation. These contingencies, although important in identifying the level of recurrent costs that project administrators must commit to, are not a valid part of project economic analysis because economic analysis is conducted in real prices as opposed to nominal prices. In general, the only price changes that are included in an economic analysis are those due to changes in relative prices over time, not those changes due to general price inflation. The decreasing energy costs from the geothermal power plant mentioned earlier is an example of a change in relative prices. There will always be some background "noise" in relative prices; the analyst should only adjust prices for those goods and services that have a substantial role in the project and that experience a clear and major change in relative price. A 1% to 5% change in relative price is probably best ignored; a 15% or larger change should be included.

2.9.4 Debt Service

Economic analysis uses a return-to-investment indicator of project viability, thus excludes all debt service payments. This has the additional advantage of divorcing decisions of project viability from the terms of financing available for the project, i.e., each project is considered on its own merits.

2.9.5 Depreciation

This item is included on financial income statements, but is excluded from financial and economic cash flow statements because it reflects an estimate of the rate the initial investment is consumed by the project, but does not reflect an actual resource

injection to the project from the economy. As economic analysis is concerned with only real resource commitments to the project, all initial investment costs are included at the time those resources are committed (and, therefore not available for alternative uses) and not when they are consumed. Inclusion of depreciation would represent double counting and therefore it must be excluded from project economic analysis. It is important, however, to distinguish depreciation from the maintenance and replacement investment required periodically throughout the project life. Maintenance and replacement investments are real resource requirements of a project and must be included at the time they are made.

2.9.6 Insurance

This cost is often confused with transfer payments because it does not seem to reflect a real resource use by the project. Accidents and natural disasters are, however, a real cost to society and to the extent insurance apportions these costs to the project, they are validly included.

2.9.7 Terminal Values

Rarely are all project resources expended by the end of the project planning horizon. Any remaining resources have a value which must be included as a benefit to the project; in uncommon cases, there may be costs, such as site restoration, which must be charged to the project. Predicting their values is not an exact science, but in general two approaches are taken. If the resource is not to be used further in the project, then its value would be determined by its alternative use which may simply be scrap, or it may be its selling price. If further use is to be made of the resource, then its terminal value can be estimated by taking the stream of benefits from the resource beyond the terminal year and converting the stream to its present value at the end of the planning horizon using the OCC as the discounting factor. A simmlar approach can be used to include the value of an environmental benefit or cost that occurs after the end of the defined project planning horizon. Referred to as an "environmental salvage value" (Dixon and Hufschmidt, 1986) this amount is calculated as a terminal value by estimating the stream of benefits and costs beyond the terminal year using the standard present value approach. Examples of this include the "cost" of a permanently destroyed fishery, or the "benefit" of a recreation area around and on a new reservoir.

2.10 Investment Criteria

Project economic analysis can provide to the decision-makers a bewildering array of cost and benefit elements spread out over time. The purpose of investment criteria is to condense the information contained in the stream of benefits and costs to a single number that depicts only the essence of the project's impact on the economic system.

In practice, there is no single investment criterion which can completely capture all of the information needed. This has led to the development of a number of alternative measures of project viability each with its own advantages and disadvantages. The measures developed can be placed in one of two general groups -- those which use discounting and those which do not. Both groups can be used to compare alternatives to achieve a single objective or can be used by the central planning agencies in their capital budgeting decisions. The emphasis here will involve assessing alternatives to achieve a single objective, which, by definition, are mutually exclusive courses of action.

Generally, these investment criteria are applied to incorporate both costs and benefits. In two cases, however, only the costs would be considered in what is known as "cost-minimization" or "cost-effectiveness" analysis, a "least cost" strategy. The first case is where benefits cannot be assigned a reliable value. For example, in certain health care projects the benefits are extremely diffuse and not observable in any market. In such a case, where the objectives of the project are justifiable on qualitative grounds, the task of the economist is primarily to ensure that the objectives are achieved at the least economic cost. The second case is where several alternatives are available which have equal benefits. The choice among the alternatives can be made by comparing only the costs associated with each, although the decision to proceed with the project must consider the benefits as well. The techniques and applicability for cost-effectiveness analysis are more fully discussed in the Annex to this Manual. In both cases analytical procedures are the same.

2.10.1 Undiscounted Measures

These measures would include such items as payback period, undiscounted benefit-cost ratios, and average annual proceeds per unit of outlay. All of these measures offer the advantage of being readily calculated, but do not consider the distribution of costs and benefits over time.

The payback period, which tells how long it would take for the net benefits of the project to equal the initial investment, does provide the decision-maker with an indication of the risk associated with securing returns, i.e., a project which returns its investment in two years is considered less risky and, therefore, superior to an investment taking 10 years. Although this is true, all other things being equal, it neglects all returns which accrue after the payback period. If the 10-year payback project returns its investment 20-fold in the 11th-year while the two-year project dies in the third year, the payback criteria would inappropriately favor the two-year project.

The other undiscounted measures are also limited in the information they convey and can even take on multiple values for a single project. For example, the undiscounted benefit-cost ratio,

i.e., the total benefits divided by the total costs, will provide a different value depending on whether an item is considered a negative cost or a positive benefit, a not uncommon situation.

The major problem with all of these ratios, however, is that the benefit (or cost) occurring today has the same value as one occurring years from now, a condition clearly not consistent with economic realities. If a cost can be delayed 10 years, then those resources can be employed in alternative uses and provide additional benefits for the 10 years before they are needed on the project. Undiscounted measures would ignore those benefits.

2.10.2 Discounted Measures

The most common of the discounted measures of project viability are the net present value (NPV), the economic internal rate of return (EIRR), annual equivalent cost (AEC), and the discounted benefit-cost ratio (B/C). The most universally accepted of these measures is the NPV.

The NPV is calculated by discounting the value of all future incremental net benefits or incremental cash flows to their present equivalent value using the opportunity cost of capital. A positive NPV would indicate that the project returns more to society than it consumes and should be accepted. The primary difficulty encountered with the NPV criteria is deciding on the appropriate opportunity cost of capital (OCC) to use in discounting the incremental net benefits since the choice of the OCC can affect the acceptance or rejection of a project over another project. If the discount rate is large, the NPV criterion favors projects with high short term net returns and conversely if the discount rate is small, projects with high long term net returns are favored.

The EIRR is calculated by finding the discount rate which will make the present value of the incremental net benefit stream of a project zero. An EIRR equal to or greater than the OCC indicates the project should be accepted. It is the maximum interest that a project could pay for the resources used if the project is to recover its investment and operating costs and still break even (Gittinger, p. 329.) Difficulties arise, however, when the incremental net benefit stream alternates in sign (negative to positive and positive to negative). This can result in more than one EIRR for the project. Also, the EIRR will not exist when the net benefit stream is either uniformily positive or negative.

The B/C criterion is defined as the present value of all cash inflows divided by the present value of all cash outflows. If the B/C ratio is greater than 1, the project is accepted.

All these critera use the same basic data on benefits and costs in the calculation. As a result, there are parallels between the values for these measures as shown in the following comparison (Dixon and Hufschmidt, 1986.)

NPV		B/C Ratio		EIRR
If >0	then	>1	and	$>i$
If <0	then	<1	and	$<i$
If $=0$	then	$=1$	and	$=i$

where i is the discount rate.

Annual equivalent cost (AEC) is included in this category because it has an element of discounting in it, but is more properly thought of as a hybrid. There are several ways of calculating the AEC, but the most straightforward is to annualize the investment costs by converting them to their equivalent annual stream using the (OCC). This, mathematically, is the opposite of finding the present value where one converts a stream of values into its equivalent present value. This annualized value is added to the operating costs for an annual equivalent cost. By itself, this number would have little meaning, so it is usually expressed in per-unit-of-output terms. For projects which have a variable output or variable annual equivalent cost, the annual values must be averaged over the life of the project. Then the average annual equivalent cost is divided by the average annual output to yield average cost per unit. The disadvantage of this measure is that the distribution of costs and benefits over time are inadequately considered.

2.10.3 Project Selection

The economist is faced with comparing two or more projects with the desired outcome being to accept some and reject others. The necessity to compare projects could be due to a number of reasons such as mutual exclusivity, economic or technical dependence, and capital rationing. For a single project or multiple independent projects with conventional incremental cash flows, (i.e., one or more cash outflows followed by an uninterrupted series of cash inflows until the end of the project's life), either NPV, EIRR, or B/C can be used to determine whether to accept or reject the project since all will provide the correct decision (two projects are called independent if the acceptance or rejection of one does not affect the incremental cash flows or the acceptance or rejection of the other.)

Unfortunately, in all other situations other than those involving a single project or multiple independent projects, the approach by which two or more projects are ranked according to their individual EIRRs, NPVs, or B/C ratios can lead to different rankings and different project selections.

For instance, conflicts in ranking mutually exclusive projects are possible using EIRR, NPV, and B/C ratios when (1) a size disparity exists between the cash outflows; (2) a time disparity exists between the cash inflows; or (3) a disparity exists in the useful lives. The inconsistency of ranking is called the reinvestment rate problem" (Bussey 1978, p. 252) because the inconsistencies can be traced to differing implicit assumptions about the rate at which cash inflows from projects are reinvested in alternative uses. The reinvestment rate explanation of the ranking inconsistency problem is not universally accepted in the literature.

Bussey's (1978, pp. 244-281) analysis indicates that the NPV method implicitly assumes the project's cash inflows will be reinvested at the OCC rate. The EIRR method implicitly assumes the cash inflows will be reinvested at the calculated internal rate of return. The B/C method implicitly assumes the project's cash inflows will be reinvested at a rate other than the OCC rate.

In the case of unconventional cash flows, the net present value method is the preferred method of project selection since the reinvestment rate for the project's cash inflows is assumed to be the OCC rate. Bussey has noted that if inconsistencies in ranking exist they can be eliminated so that all methods provide the same results by specifying a "common" reinvestment rate for the cash inflows. The opportunity cost principle requires that this common reinvestment rate be the best alternative use available for the cash inflows, i.e., the OCC rate.

2.11 Sensitivity Analysis

Economic analysis of projects requires the estimation of diverse data elements -- historical and forecasted values -- for developing the cost and benefit streams. All too often, estimation of items is made from data containing a significant amount of measurement error and from assumptions and judgments that result in uncertainty about the estimated values. The role of sensitivity analysis is to test the effects on a project's expected performance by varying the values of the data elements that form project's costs and benefits.

Sensitivity analysis identifies variables that have the most influence on NPV and EIRR by systematically testing each one. Although this can entail examining a large list of variables, the list can usually be narrowed to a few key data elements via less formal evaluation. For example, if the quantity of an input and its price are small relative to other inputs, such that their product represents a small fraction of total cost, then variation in either estimate -- quantity or price -- should not greatly affect NPV or EIRR.

Another approach to sensitivity analysis involves the calculation of "switching values," sometimes called cross-over values. For each variable, the switching value causes the NPV to become zero, the minimum value of acceptance for a project. In terms of the EIRR, it is the value that equates the rate of return to the OCC rate. Examples of switching value calculations can be found in Chapter 3, Section 3.8. Gittinger discusses the concept in his 1982 book on pp. 371-373.

The principle to be observed in deciding whether or not the project outcome is sensitive to the variation of a parameter is based upon probabilities of occurrence. When switching values are calculated, sensitivity is indicated when the probability of that value occurring is significant. This probability is generally lower for larger differences between the expected value of a parameter and its switching value, but this is by no means always the case. Similarly, when a small change to a parameter causes a large change in the NPV or EIRR, the project outcome is said to be sensitive to the parameter. When ranges of parameters are used to test for sensitivity (as opposed to calculating switching values), the classification of parameters into sensitive and nonsensitive categories is facilitated by using ranges that have uniform probabilities associated with each. That is, if investment costs and output prices are tested for sensitivity, the percentage increases or decreases used for each should have the same probabilities associated with them even though this causes the percentages to differ. Such probabilities can seldom be estimated with certainty, but the quality of a sensitivity analysis is improved if the probability distribution can be estimated.

In practice, variables tested for sensitivity vary from project to project but several types are frequent candidates, either because of the uncertainty surrounding them or because they usually affect large portions of costs or benefits. These are the shadow price factors (particularly the SWR and the SER), the investment costs, and the benefits of the project. The latter represent a more complex case because of the impact transmission mechanism by which benefits are realized. The operation of this transmission mechanism can involve a number of intermediate outputs and inputs before reaching the ultimate benefit, making the sensitivity analysis of benefits a complex task.

As a final caveat, the economist should be aware of the possible interaction of variables in sensitivity analysis. Varying one variable while holding all others at their expected values is not realistic if the variable of major interest is correlated with other variables. In the case of joint determination, the variables should be varied jointly.

2.12 Risk Analysis

Sensitivity analysis usually precedes risk analysis by first identifying the key variables on which the success of the

project depends. By itself, sensitivity analysis does not completely address uncertainty in the estimates; it only identifies which variables most affect the outcome of the project.

The role of risk analysis is to ultimately estimate the probability distribution of the project outcome based on estimates of uncertainty (probability distributions) in the key variables identified in the sensitivity analysis taken together. This will lead to an assessment of how to reduce risk through better estimates (lower uncertainty) of key variables, and through design or operational changes. It also supplies the decision-maker with additional criteria used in judging the viability of the project.

Risk analysis can be accomplished by a wide range of techniques, the most common of which is to use the results of the sensitivity analysis along with subjective appraisals based on experience with other projects. As such, it is more an assessment of the sensitivity analysis rather than a distinct analytical step.

At the other end of the spectrum are the highly sophisticated computer models utilizing quantitative assessments of the probability distributions of project outcomes. The efficacy of quantifying project risk in this manner is a question that must be made on a project-by-project basis. There is no need for quantification of risk if: (1) the NPV or EIRR for the project are so high that the expected value of either is likely to exceed the minimum requirements; (2) only one or two variables significantly affect the NPV or EIRR such that simple sensitivity analysis will point to what needs to be done to reduce the risk of failure; and (3) the required changes to project planning that will reduce risks or ensure against special hazards are obvious. If a sophisticated risk analysis is to be conducted, a good reference would be Reutlinger (1970) and Proplan by Szekeres (1986).

CHAPTER 3

PERFORMING ECONOMIC ANALYSIS OF PROJECTS

This chapter provides a step-by-step procedure for the economist to follow in conducting project economic analyses based on the principles presented in Chapter 2. The procedure strives to answer the following questions which this chapter will address in some detail utilizing a fictitious project for illustrating the required methods and calculations.

- How to get started for the specific project given the budget and time available;
- How to prepare the financial cost information so as to construct the financial cost-flow statement;
- How to identify costs and benefits using a systematic approach that looks at all changes resulting from the project;
- How to determine and use economic prices to obtain the economic benefits cost flow statement;
- How to use investment criteria to compare costs and benefits; and
- How to develop alternative scenarios to test the robustness of the results by using sensitivity analysis and risk analysis.

In applied work, the economist should exercise caution because the application of economic analysis in the public sector is both an art and a science. Although a step-by-step procedure is presented here, the art of economic analysis will require the economist to draw on creative capabilities and judgment in applying or adapting these methods to a particular case in the field.

3.1 An Overview of the OSB Sample Case

Clearly, a single hypothetical project cannot cover all circumstances the economist will face in performing economic analysis for the diverse projects undertaken in developing countries. The objective in presenting a single case in this chapter is to provide sufficient elements to discuss the major concerns and problems economists face in project analysis within a consistent framework. This provides the necessary continuity for presenting the various stages of analysis which comprise the methodology for economic analysis of projects. In addition, the worksheets presented in this chapter provide a comprehensive system

for appraising all projects, but it may not be possible to follow the system rigidly in all cases, because of data problems or the nature of the project in the field.

3.1.1 The Project Outputs

The project involves the construction of a new industrial plant which utilizes a new technology for making sheathing and flooring panels. These items are used in building construction for walls and floors. The new technology, called oriented strand board (OSB) construction, makes these panels out of less expensive sweet gum hardwoods together with the more expensive softwoods used by the existing technology for plywood construction. With an overabundant supply of sweet gum in our fictitious country, the OSB technology represents a new opportunity for the country to make use of its underutilized resource.

The two products are treated differently to broaden the scope of issues addressed in this chapter. The first product, sheathing panels, will be used to replace imports: an "import substitution" product. This product provides an example for illustration of the "import parity price" concept and how local and foreign components are calculated to allow for shadow pricing the foreign exchange component.

The entire output of flooring panels will be used domestically and will replace the output of an existing plywood plant that will be phased out over the first four years of the project. Technically, the flooring panels are tradeable and, therefore, a world price should be used in the benefits calculation for this product. Instead, this product will be treated as a nontraded output to simplfy the calculations. This allows the discussion to focus on the question of how to treat output that only substitutes for current domestic supply.

3.1.2 The Project Inputs

The domestic wood supplies of hardwood will have to be harvested and treated as part of the project because without the project, the harvest would not take place. As part of the logging operations some rural roads will be upgraded. The benefits of the road improvements will be estimated in the project. In addition, the environmental costs associated with logging and road construction need to be considered and included in the calculation. Another project input is currently exported and, therefore, the projects's use of the input will illustrate a "diverted export" situation. Still other inputs will represent the case of nontraded goods with traded components.

3.1.3 Shadow Prices

Because the project is an industrial plant, very little unskilled labor is employed in the operation of the plant. Therefore, this component will not be a major cost item, but the case will illustrate the calculation of a shadow wage rate. The shadow exchange rate is an important calculation for this project because of the traded status of the sheathing panels and some of the inputs. The trade-based approach discussed in the previous chapter will be employed for this calculation.

3.1.4 The Worksheets

Throughout the chapter a number of worksheets will be used to organize the calculations required by the project, and to summarize the economic cash flows over the life of the project. These worksheets are meant to serve as general guidelines and are not intended to fit every project without some changes to accommodate the particular aspects of a project. In general, these worksheets can be defined as follows:

Worksheet 1: This worksheet lists the physical inputs and outputs of the project with initial quantity and/or price estimates as they exist at the early stages of the project. By listing the inputs and outputs, worksheet 1 forces the project team to consider the details of the project.

Worksheet 2: This worksheet represents the financial analysis cost- flow statement (no revenues are included). This data will be provided from the financial analysis which normally precedes the economic analysis of a project. The quantities and prices from this stage of the analysis provide the initial estimates to be adjusted according to the opportunity cost and willingness-to-pay criteria of the economic analysis.

Worksheet 3: This worksheet lists all the impacts of the project on the economy and environment that have been identified using the impact transmission mechanism. The worksheet also identifies whether the item is a benefit or a cost, whether it is classified as traded or nontraded, and whether any transfer payments are involved.

Worksheet 4: This worksheet takes the items from worksheet 3 and determines whether adjustments to the market prices are needed to conform to economic efficiency criteria. For each item, the foreign, local, and unskilled labor components are identified, so that the shadow exchange rate, and shadow wage rate can be applied to the proper amounts.

Worksheet 5: This worksheet displays the project's cash flows from the economic analysis before shadow pricing the foreign and unskilled labor components. The worksheet only displays the with-project benefits and costs. Without-project benefits and costs are shown in Worksheet 6.

Worksheet 6: This worksheet summarizes the results of the economic analysis. It shows the with-project and without-project benefits and costs by foreign, local, and labor component. Incremental net benefits are shown with and without shadow pricing, along with the net present value, the economic internal rate of return, and discounted benefit/cost ratio of the project's incremental net benefits.

3.2 Beginning the Analysis

The objective of this step is to develop the project definition. This entails establishing the boundaries of the analysis, listing the direct physical inputs and outputs; selecting the appropriate analytical technique given such factors as the time available, the budget, the type of project, and the stage of the analysis; and considering alternative formulations to meet the project's objectives.

3.2.1 Project Definition

Without a proper project definition, the economic analysis will be exceedingly difficult to conduct and to present coherently to decision-makers. The project definition begins by relating the project to the macroeconomic and sectoral objectives that it proposes to achieve. For instance, the illustrative case involves an oriented strand board (OSB) plant to manufacture structural panels. The output of this plant will help to achieve the national objective of developing the rural economy through increased utilization of the country's hardwood timber resources.

3.2.1.1 Project Boundaries. With the project's relevance to national objectives established, the economist must define the boundaries of analysis, i.e., determine what to include and exclude in the analysis. In conceptualizing a project to help achieve a national objective, a single activity or series of activities -- which may or may not be interrelated -- will most likely be suggested. For instance, to increase the utilization of less expensive hardwood timber resources, an OSB plant will be built near the port city; however, to provide access to the timber resources, a gravel road between the rural logging area and the plant will have to be paved. The project definition for the economic analysis should include all (and only) interrelated activities which, in this case, comprise the OSB plant and the rural road improvement.

There are cases where distinct activities are funded by separate agencies -- the multi-donor situations. For example, the economic analysis of the OSB plant must include both the plant and the road, even if the World Bank is funding the OSB plant and A.I.D. is funding the rural road improvement. The costs of the logging operation for this example are not included in order to keep the details of this case more presentable. But it should be noted that those costs are within the boundaries of this OSB project, as are the environmental effects of logging and the building of the road (included implications of the increased access to the area by potential settlers).

3.2.1.2 Listing Physical Inputs and Outputs. With the boundaries of the project defined, the economist now prepares a list of the physical inputs and physical outputs (often referred to as the technical inputs and outputs or direct effects) based on information provided by the technical staff about the production process. Worksheet 1 illustrates this task for the OSB model plant. It is important for the economist to collect initial quantity estimates for the inputs and outputs, as shown in Worksheet 1, to provide data required for a quick "magnitude analysis."

The obvious physical outputs for the project are the two types of OSB panels to be manufactured. However, physical outputs that are frequently overlooked but need to be identified are those by-products or residuals from a project which, in this case, are wastewater and air pollutants. This stage of identifying outputs relates only to those directly generated by the project. A more comprehensive identification of the environmental changes attributable to the project is undertaken later with the impact transmission mechanism.

Physical inputs for the OSB project are also listed in Worksheet 1, with initial estimates given where possible at this stage. Also, the physical inputs are divided into investment costs and operating costs.

Worksheet 1

Listing of Primary Physical Inputs and Outputs

Item	Initial Quantity Estimates: Quantity	Units
Physical Outputs		
1. Sheathing panels, 1/2 inch	60,000,000	square feet/yr
2. Flooring panels, 19/32 inch	50,000,000	square feet/yr
3. Wastewater	no estimate	
4. Air pollutants	no estimate	
Physical Inputs		
1. Investment Costs		
Land/site prep	30	acres
Buildings/structures	150,000	square feet
Equipment		
Processing equipment	9 to 13	million US$
Boiler & fuel system	6 to 7	million therms
Other	40 to 60	million pesos
Installation & freight	no estimate	
Roads for logging operation	6 to 10	miles
2. Operating Costs		
Wood, sweet gum	55,000	cords/yr
Wood, pine	53,000	cords/yr
Chemicals, dry resin	14,000,000	lb/yr
Chemicals, dry wax	2,000,000	lb/yr
Labor, administrative	6	
Labor, plant	120	
Electricity	28,000,000	kWh/yr
Boiler fuel	wood wastes	
Other supplies	no estimate	
Taxes	no estimate	

3.2.1.3 Project Alternatives. At this early stage, the economist needs to begin to consider appropriate alternatives to achieving the project's objectives. In other types of projects, there may be many alternatives to consider initially, but in most cases, technical (whether or not an alternative is even feasible) and other considerations can reduce the number to only a few. Regardless of how many viable options are considered, cancelling the project remains as one alternative.

No alternatives to the OSB plant will be presented, but the kinds of alternatives which could be investigated include:

- locating the plant near the forests rather than the port,
- a different size of facility,
- an expansion to plywood manufacturing (rather than OSB),
- a phased development of production capacity, or
- an alternative use of the wood to increase exports rather than substitute for imports.

3.2.2 Magnitude Analysis

The economic analysis would probably be most useful at the project prefeasibility stage and not at the project paper stage where it can have little impact on forcing the review of alternatives. The problem the economist faces is that at the project prefeasibility design stage the analysis must be conducted in a short period of time. This obviously does not allow for any detailed analysis. In this case, a short-cut method called magnitude analysis can be employed.

While precise answers are not possible using the magnitude approach, it has proven useful as a quick screening technique. With the OSB model, the magnitude approach starts with a crude estimate of total investment cost derived from Worksheet 1, which the economist estimates at 524 million pesos. The question the economist must now address is, "What magnitude of benefits is needed to justify the 524-million-peso project cost?" For example, does the 524-million-peso investment require an unrealistic price for OSB panels relative to the price for competing plywood panels? If so, the magnitude analysis may conclude that under the conditions set forth in Worksheet 1, the OSB plant is not a wise investment. An alternative structuring of the project may make it more viable.

3.2.2.1 An Example. To answer the question posed in the previous paragraph, the economist must first estimate output quantity over the planning horizon. In addition, a rough estimate of production

costs per unit is needed to generate a total cost stream through the period. All of these estimates are derived from the data in Worksheet 1 and from additional inquiries to estimate prices where none is shown. Total investment costs would then be estimated as:

Rough Estimate of Total Investment Costs

Item	Quantity	Price	Cost (Million Pesos)
1. Land	30 acres	1,060,000 P/acre	32
2. Buildings	150,000 sqft	500 P/sqft	75
3. Equipment			
Processing			220
Boiler	7 million therms	6 P/therm	42
Other			60
Install/freight			70
Subtotal			392
4. Roads	10 miles	2,500,000 P/mile	25
Total Investment Cost			524

An estimate of total operating costs per unit derived from Worksheet 1 and additional estimates of average prices for each item is produced in a similar table shown below.

Rough Estimate of Total Operating Costs

Item	Quantity	Price	Cost (Million Pesos)
1. Wood, sweet gum	55,000 cords/yr	700 P/cord	38.5
2. Wood, pine	53,000 cords/yr	1,200 P/cord	63.6
3. Dry resin	14 million lbs/yr	8 P/lb	112.0
4. Dry wax	2 million lbs/yr	5 P/lb	10.0
5. Labor, admin	6	100,000 P/yr	.6
6. Labor, plant	120	40,000 P/yr	4.8
7. Electricity	28,000,000 kwh/yr	2 P/kwh	56.0
8. Other supplies			20.0
Total Operating Cost			305.5

Given that operating costs are approximately 306 million pesos per year, the estimated output levels from Worksheet 1 indicate that an average price of 2.78 pesos per square foot (P/sqft) (306 million pesos divided by 110 million square feet) is required to at least cover these costs. Because the current market prices for these items are well above this level, there is reason to believe that the project can be viable.

To account for the investment costs, the economist should look at a cash-flow stream and calculate the internal rate of return from these rough estimates to get a better indication of how the project will perform. Using the world price of the sheathing panels at 4.0 P/sqft and the domestic price of flooring panels at 5.5 P/sqft, the estimated output figures will generate 240 million pesos and 275 million pesos, respectively. Total revenue is 515 million pesos for a net cash flow of 209 million pesos (515 - 306) at full production. Using these figures, a planning horizon of 25 years with a two-year construction phase and two-year start-up phase (50% of full production), and a discount rate of 12%, the economist calculates an internal rate of return of 28%. These results indicate that the project is viable as planned and, therefore, a more detailed analysis is justified to fully evaluate benefits and costs, including environmental and other effects (See paragragh 3.10 Chapter Notes for details).

Obviously, the magnitude analysis should be used with extreme caution and only as a screening technique to identify possible viable project alternatives. Each of these viable alternatives should be subjected to a thorough economic analysis, but in practice this is not always feasible because of time and budget constraints. The one danger in using magnitude analysis for screening alternatives is that because of its imprecision, a viable alternative may be rejected when more thorough analysis would have accepted it.

3.3 Preparing the Financial Cost Information

The objective of this step is to illustrate how to construct the financial cost-flow statement from financial data. The information contained in the cost-flow statement will be used later in determining the project's economic costs. For the OSB plant, the financial cost-flow statement is shown as Worksheet 2 with all costs in real terms. In any project, all costs can be classified in one of the following categories: (1) investment costs, (2) operating costs, and (3) other costs. Phases of the project shown in Worksheet 2 are defined as follows:

* CONSTRUCTION is that period when costs are incurred, but benefits are usually not produced;

* START-UP is that period when operations are begun, but full capacity has not been reached;

* FULL OPERATION is that period between start-up and the end of the project planning horizon; and

* TERMINAL VALUE is used to record any residual value in the project at the end of the planning horizon.

Worksheet 2

Financial Cost-Flow Statement
(millions of pesos)

Phase	Construction		Start-Up		Full Operation			Terminal
Output %	0%	0%	50%	75%	100%	100%	100%	Value
Year	1	2	3	4	5 -- 18	19	20 -- 25	25
CASH OUTFLOWS								
Investment Costs								
Fixed Capital								
1 Land/site preparation	32							16
2 Buildings/structure	20	40						0
3 Equipment								
Processing equipment		232						0
Boiler & fuel system		36						0
Auxiliary		44						0
Electrical		18						0
Installation		86						0
4 Road improvements	10	12						0
5 Engineering & Const Mgmt	20	32						0
6 Contingencies		40						0
Total Fixed Capital	82	540						16
Working Capital (incremental)			17	20	0	0	0	37
Replacement Capital (Boiler)			0	0	0	18	0	
Operating Costs								
1 Raw Materials								
Wood			49	74	98	98	98	
Chemicals			53	80	106	106	106	
2 Labor			6.9	10.3	13.7	13.7	13.7	
3 Administrative			2	3	4	4	4	
4 Electricity			28	42	56	56	56	
5 Supplies			9	14	18	18	18	
6 Taxes			2	3	4	4	4	
Total Operating			149.9	226.3	299.7	299.7	299.7	
Total Cash Outflow	82	540	166.9	246.3	299.7	317.7	299.7	
Total Residual Value								53

The importance of each cost category will vary considerably for different types of projects. For instance, a training program would most likely require a small investment but large year-to-year operating costs, whereas the OSB plant has both significant investment and operating costs. In developing the financial data, the economist should be interested in identifying which cost category will account for the majority of the costs and should be most concerned with the precision and reliability of these cost estimates. In addition, all cost estimates should be referenced to their sources, and when they are calculated from several data items, the method of calculation should be shown and the basic assumptions clearly stated.

3.3.1 Investment Costs

Investment costs or capital costs can be defined as the sum of fixed capital required for constructing and equipping a project to obtain the desired outcome, the working capital required to operate the project, and any replacement investments required over the life of the project (planning horizon).

3.3.1.1 Fixed Capital. Fixed capital costs are defined as the sum of fixed investments and pre-operating capital costs. Fixed investment costs can be further segmented into either initial or replacement. The initial fixed investment for the OSB plant includes land and site preparation, buildings, equipment, road improvements, and contingency allowances. When the initial fixed investment costs include the interest during construction, the interest component should be identified for later exclusion. Pre-operating capital expenditures for the plant include engineering and construction management. Items which the interest component included in this category are pre-investment studies, management of project implementation, detailed planning, testing equipment, and recruitment and training of staff. Worksheet 2 indicates the timing of total fixed capital expenditures for the OSB plant will be 82 million pesos during the first year of construction and 540 million pesos during the second year.

Contingency allowances are frequently associated with estimates of initial investment for a project, especially those which require significant construction over several years as in the case of the model OSB plant. The economist should segment those allowances to be included in the economic analysis, such as physical contingencies (e.g., adverse weather) and price contingencies for unforeseen changes in future relative prices of project inputs. Allowances for price contingencies due to general inflation are not a part of the economic analysis because all prices are in real terms. In the example, it is assumed that all the contingency allowances are based upon an expected general increase in prices so they will not be included in the economic analysis (shown in Worksheet 5 later in the chapter).

Occasionally, contingency allowances are also included in projects with respect to the amount of inputs, such as raw materials and labor, required to obtain the desired outcome or product. Physical contingencies can affect estimates of the amount of inputs required. One procedure used to estimate these contingency costs is to add a percentage, usually between 5% and 10%, to the physical volume required by the inputs.

An examination of the proposed investment in the OSB plant indicates that no "sunk" costs -- historical investment in facilities which the proposed plant could utilize -- have been included. Sunk costs under most circumstances should never be included as part of the proposed project's investment because they have already been paid. The investment made for a project started earlier but uncompleted normally would not be included in the analysis of whether to proceed with the project. The only circumstance where sunk costs would be included is when they have a market value or opportunity cost, such as buildings or land that could be sold. Failure to include the value of such assets often leads to unrealistically high rates of return on rehabilitation projects.

Replacement investment refers to those capital items which have a useful life less than the planning horizon of the project. For the OSB plant, the boiler will have to be replaced in the 19th year of plant operation as shown in Worksheet 2. The economist must recognize that the future replacement cost may differ from the historical original cost even assuming zero inflation. In the OSB plant, the lower cost does not represent falling real prices of boilers, rather it indicates that only part of the boiler system requires replacement after 18 years.

3.3.1.2 Working Capital. Consideration of working capital as a part of the total project investment is necessary for nearly all projects. Working capital requirements are determined for the initial year and can increase in future years as the project becomes fully operational. Only annual increments to working capital are shown in the cost-flow statement; cumulative amounts are not.

In manufacturing projects, such as the OSB plant, working capital requirements would cover such items as the difference in accounts receivable and accounts payable, minimum inventories of raw materials, minimum stocks of goods in progress and finished goods needed to efficiently produce a product in a year, and the required cash in hand. A systematic method for determining incremental working capital requirements is found in UNIDO (1978, pp. 156-157). For the OSB plant, working capital requirements are estimated as:

1.	Three months' salaries pesos	11.4 million
2.	One month of raw materials pesos	17.0 million
3.	One month's accounts receivable pesos	38.6 million
4.	Minus one month's accounts payable pesos	-30.0 million
	Total working capital pesos	37.0 million

These costs are phased in during the first two years of construction as shown in Worksheet 2.

As the operation expands, working capital requirements increase as well. In his 1982 book on economic analysis of agricultural projects, J. Gittinger recommends that incremental operating capital range between 80% and 100% of incremental operating costs. Incremental working capital requirements for a year then would be between 80% and 100% of the difference in operating costs for the year being examined and the next year. Gittinger's rule of thumb, however, may prove inaccurate, as he points out, in seasonal projects where peak working capital can be very high. It should only be used when time and data constraints do not permit working capital to be estimated more precisely.

3.3.2 Operating Costs

The operating costs associated with the OSB plant are based on inputs such as raw materials, labor, administration, electricity, and production and maintenance supplies. In the financial cost-flow statement for the plant, the percentage of full operation for the period is displayed above the data for each year. These percentages are reflected in the operating costs by simply multiplying the full-operation costs by the percentage indicated for the start-up periods.

Operating costs are, of course, dependent on the type of project at hand. Because operating costs are determined in future years, eventually in years very distant from the construction phase, the required quantities and prices are difficult to forecast. These are some of the most demanding calculations facing the economist, which is one reason for the contingency allowances. For projects with quantifiable, revenue-generating output, the benefits must be large enough to surpass operating costs and meet the country's criteria for project acceptance. In nonrevenue-generating projects, the economist must determine if the borrowing agency has the

necessary resources to cover the recurrent costs generated by a new project after completion of the loan. Too often this fact is overlooked during project analysis with unfortunate consequences after implementation of the project.

3.3.3 Other Costs

The economist needs to identify and display any taxes for the OSB plant as shown in Worksheet 2. In addition to taxes, other costs would include duties and tariffs as well as dividends for revenue-generating projects. These costs are broken out separately in Worksheet 2 because they represent transfer items that will be excluded in the economic analysis. Transfer items will be discussed in the section on economic prices.

3.3.4 Project Planning Horizon

The economist must determine how long the project's product or outcome will be useful. The planning horizon, or life of the project, is generally taken to be the economic life of the longest-lived capital asset. This may differ from the time the capital asset can physically continue its service. Because of technological advances, new equipment may reduce operating costs to the extent that maintaining the "old" equipment is no longer economically viable. In this case, the "old" equipment should be replaced with the new -- the economic life of the old equipment turns out to be less than its physical life. But in project analysis, forecasting such changes in technology is impractical, thus the physical life of the asset is used instead.

In some projects, such as educational or institutional development, it is difficult to determine what the project life should be, and in such cases the economist will have to exercise sound judgment. Of practical importance in this decision is that the present worth of items entering 25 years and beyond is quite small because of the discounting effect. Therefore, projects are rarely evaluated over more than 25 years. In the case of the OSB plant, we choose 25 years because the expected life of the plant is longer than 25 years.

3.3.4.1 Terminal Value. At the end of a project, the remaining assets need to be evaluated to determine what residual value they still possess. The terminal values of the project assets are difficult to estimate, but, fortunately, precision is not usually required for these estimates because their present values are small due to discounting. For projects with relatively short time horizons, the terminal values will take on more importance, and, therefore, require more precision.

Terminal values are derived for various assets -- for example, equipment where the resale value is often close to zero, or assets such as land which may have increased in value due to

improvements such as irrigation. Another terminal value is the working capital remaining after liquidation of stocks, accounts receivable, accounts payable, etc. For the financial analysis, terminal values should be estimated by their market value in the terminal year, while for the economic analysis terminal values must be expressed in real terms.

Land, which retains its value in perpetuity, can use its initial purchase price (in real terms) for the terminal value unless the value of the land is expected to increase or decrease over the planning horizon. In industrial projects, it is commonly assumed that the equipment has nothing more than scrap value at the end of the period. For the OSB model, we have assumed the land purchased for the plant will retain its value (which is one-half the amount shown in the "Land/Site Preparation" line item of Worksheet 2). All equipment is assumed to have only scrap value at the end of the planning horizon.

3.4 Identifying Costs and Benefits

The objective of this step is to use the information developed from the listing of primary physical inputs and outputs (Worksheet 1) and the financial cost-flow statement (Worksheet 2) to systematically identify the project costs and benefits as shown in Worksheet 3. The purpose of Worksheet 3 is to show clearly the linkage between the project's physical inputs and outputs and the identified costs and benefits.

Benefits and costs are described using terms such as direct effects and secondary effects, tangibles and intangibles, pecuniary externalities, and technological externalities. Because these classifications are not necessarily mutually exclusive and because they can be potentially confusing to decision-makers, it is important to derive an analytical, systematic method for identifying the changes attributable to the project that result in benefits and costs. Also, as emphasized in Chapter 2, the with/without analysis must be used to correctly quantify benefits and costs. This means taking account of what would happen without the project over the period being analyzed. Because projects are meant to alleviate problems, it is likely that, without the project, these problems will only grow worse.

As pointed out in Chapter 2, changes that result from a project must be examined with respect to particular criteria to determine if they positively or negatively affect society's welfare. To make this determination, each of the project's inputs, outputs, and impacts should be subjected to the following question: does the input/output/impact either increase or reduce national income? Or stated another way: does the input/output/impact either increase or reduce the value of a final good or service?

Transfer payments are items included in the financial analysis that invoke a negative response to these questions. These are payments between segments of the nation's economy that do not represent the use or addition of real resources. For this reason, they are removed from the valuation of benefits and costs in the economic analysis.

3.4.1 Classifying the Physical Inputs/Outputs

Worksheet 3 is designed to organize labeling of the physical inputs and outputs as benefits or costs and as traded, nontraded, or transfer items. These steps precede the valuation of benefits and costs in terms of their economic prices rather than their market prices used in the financial analysis. It also allows for initially identifying impacts generated from the physical inputs and outputs but not considered in the financial analysis. For the OSB model, an example of an impact resulting in a benefit is the reduction in transportation operating costs on the improved road. An impact resulting in a cost is represented by the adverse effect of logging operations on fishing in the river basin, namely, from the erosion due to deforestation.

3.4.1.1 The Impact Transmission Mechanism. The impact on society of the majority of the inputs and outputs can be determined reliably using the economic price of the input or output. For others, such as the impact of the logging operations listed as Item 7 under Physical Inputs of Worksheet 3, the impact is not so obvious -- the "impact transmission mechanism" must be specified. This is the causal chain that relates the initial physical input/output (e.g., wood from logging) to the final impact (e.g., reduction in fishing income). Figure 3-1 illustrates this chain in four steps.

First, the input is identified (step 1) -- the wood from the logging operation to be used as a physical input by the OSB plant. Next, the impact on the soil resulting from harvesting the trees for the wood is identified (step 2) -- erosion will occur before the seedlings can be established. After the erosion impact is determined, the consequence of this erosion is identified (step 3) -- it will adversely affect the fish population of the nearby river. Lastly, this impact can be estimated in monetary terms (step 4) -- lower fish yield reduces the incomes of the residents that rely on fish for income generation or for family food production. In addition to the effects of erosion and increased turbidity on fish production, other effects may occur and should be included, in monetary terms when possible, in the economic analysis. For example, the logging operation and land clearing may result in reduced future forestry production if the erosion reduces the fertility of the soil. The eroded soil may also end up as a sediment behind a downstream reservoir and dam. This can result in major costs from reduced hydropower generation, reduced availability of irrigation water, or reduced flood control capacity. These are all examples of "environmental effects" that impose real, direct costs on society.

Worksheet 3

Linkages of Benefits and Costs
to Physical Inputs and Outputs

	Economic Analysis Considerations	Ben/ Cost	Traded	Non-traded	Transfer
Physical Outputs					
1 Sheathing panels	(a) Panels will substitute for current imports, (b) current imports are now subject to an import duty.	B	x		x
3 Flooring panels	OSB boards will replace locally produced plywood panels.	B		x	
4 Waste water	Effluent from the plant discharged into river; affecting water quality for nearby populations; possible need for waste treatment plant.	C		x	
5 Air pollutants	Smoke from burning wood wastes in boiler will affect air quality. Incremental impact to be assessed.	C		x	
Physical Inputs					
1 Land	Plant is located near population center; competitive market--can use market price.	C		x	
2 Buildings/ structures	(a) Uses imported materials with no duties, (b) uses domestic materials and unskilled labor.	C	x	x	
3 Equipment/ processing	(a) all processing equipment is imported, (b) duties are applied.	C	x		x

Worksheet 3 (continued)

Linkages of Benefits and Costs
to Physical Inputs and Outputs

Physical Inputs	Economic Analysis Considerations	Ben/ Cost	Traded	Non-traded	Transfer
4 Equipment/ boiler	Boiler and fuel system is domestically produced and industry has excess capacity.	C		x	
5 Equipment/ other	(a) some traded components (b) locally produced items.	C	x	x	
6 Installation	All local materials and unskilled labor.	C		x	
7 Wood	Lag in regrowth results in erosion, increasing the deposit of soil and debris in lower river basin.	C		x	
8 Wood	Roads for logging operation will improve transportation in area.	B		x	
9 Wood	Roads to be developed by project.	C		x	
10 Chemicals	Previously exported, will be diverted to project below f.o.b. price.	C	x		
11 Labor	Skilled labor and unskilled labor (in abundant supply).	C		x	
12 Electricity	Connection to local grid.	C		x	
13 Production and maintenance supplies	(a) some imported oil products, (b) domestically produced otherwise.	C	x	x	
14 Taxes	Sales taxes on domestic products, and license fees.				x

Figure 3-1

Illustration of the Impact Transmission Mechanism

Impact Mechanism	Comments
Domestic Wood	Logging operations for supplying wood input requirements.
↓	
Soil erosion	The cleared land causes erosion during the frequent rainfall in the near term before regrowth can retard it.
↓	
Increase in runoff	Rainfall will carry debris and soil from the deforested lands into the river, increasing turbidity.
↓	
Reduced fish	Increased turbidity reduces spawning.
↓	
Final impact is a reduction in incomes of local fisherman	Need to quantify the reduction in fisherman's income loss.

Some of the impacts identified as benefits and costs in Worksheet 3 are externalities from the perspective of the financial analysis (see Section 2.5). The economic analysis addresses externalities by first tracing the causal chain to a point where the benefit or cost can be priced, and then quantifying the impact in monetary terms for inclusion in the economic analysis as direct costs or benefits. During the process of tracing and quantifying the impact, the economist must be wary of double counting. This is one of the reasons why the process stops at the first identifiable 'market' where a monetary quantification can be achieved.

Externalities are often thought of only as environmental impacts, but they encompass much more than this. For example, the benefit from the road improvements in the OSB project is an externality as well as the cost associated with the loss in income to fishermen from the logging operations. In general, the economist must expand the project boundary defined by the financial analysis to include these physically distant impacts on the air, water, soils, animals, and humans. For any environmental impact attributable to the project, the following set of questions provides a means for identifying environmental impacts:

- is there any real output or production that is destroyed or not undertaken, or
- are any resources or productive inputs destroyed or caused to lie idle, or
- is there any loss of consumption or wealth?

In other cases, the relationship between the project's output and its value to the economy is not clear. For example, using a project to train X agricultural extension supervisors cannot be immediately translated into a quantifiable impact on society. An impact transmission mechanism must be specified to link the X agricultural extension supervisors to their impact on crop production of Z amount in future years. The X agricultural extension supervisors (an intermediate physical output) will lead to Y number of additional farmers adopting the preferred technologies with an increase in production of Z (the final physical output) in year 1, and beyond.

3.4.1.2 Classification. In Worksheet 3, the left column lists the physical outputs followed by the physical inputs. The next column provides a brief note on economic pricing considerations -- the precursor to final assignment of economic prices to benefits and costs. To the right of this column, each entry is labeled as a benefit (B) or a cost (C), and to the right of these labels are the traded, nontraded, and transfer distinctions.

In general, "traded" items are those that affect the country's foreign exchange balances and "nontraded" items are those that do not. An exception occurs when an item is not traded by the country, but could be because an international market exists and the relevant port through which trade would occur does not cause transportation costs to prohibit trade in the item. In some cases, an item can have both traded and nontraded components, as shown in Worksheet 3. In these cases, a domestic good uses imported materials in the manufacturing process. The distinction between traded and nontraded is required for splitting costs and benefits between local components and foreign components, so that the latter can be adjusted with the shadow exchange rate (discussed in the next section). The "transfer" item label is required so that these monetary values can be removed from the accounts when doing the economic analysis.

The first entry in the worksheet -- sheathing panels -- will substitute for current imports. Although they will not be exported, they substitute for an import which is the basis for their benefit calculation, therefore they are labeled "traded." The "transfer" label is also used because the imported panels are subject to an import tariff which must be removed in the economic analysis. For simplicity, it is assumed that the flooring panels will be used domestically and are treated as a nontraded output. We are using the flooring panels to examine the case of a country attempting to upgrade an existing technology. The OSB flooring panels will substitute for domestic production of plywood panels using an outmoded technology. Because they don't add to domestic supply, the revenue lost and resources saved from the displaced production must be included in the project accounts.

In Worksheet 3, wood is listed more than once in the physical inputs section, denoting multiple impacts. In more complicated projects, it is conceivable that many physical inputs and outputs will have multiple impacts and therefore must be listed more than once. Complexity also increases the chance of double counting costs or benefits, which is another reason for being systematic about listing all impacts of the project.

3.5 Determining Economic Prices

After all benefits and costs have been identified, a transition from market prices to economic prices is required to proceed with the economic analysis. The distinction between financial and economic analysis was discussed in Chapter 2. Try to keep the principles of that discussion in mind as we trace the methodology for identifying project input and output impacts and for determining what adjustments must be made to market prices for the economic analysis.

3.5.1 A Decision Tree for Assigning Economic Prices

At the completion of Worksheet 3, the economist has classified all the impacts attributable to the project's physical inputs and outputs as either benefits or costs. The task now is to assign economic prices to these benefits and costs. A flow diagram (from Gittinger's 1982 book on economic analysis, pp. 282-283), referred to as an economic-price decision tree, is reproduced, with slight modifications, as Figures 3-2 through 3-5. These diagrams are quite useful in organizing the process of assigning economic prices.

The two main branches of the tree, Figure 3-2, begin the process by first dividing items to be valued into tangible and intangible. Tangibles are then separated into direct transfer items, which are removed from the economic analysis, and items involving real resource use, which must be valued. Because intangibles cannot be valued they are removed from the economic pricing tree, but they should be identified and quantified as best as possible. Many environmental goods and services (e.g. genetic material pools, biological diversity, aesthetic concerns) are commonly considered as intangibles. If they cannot be quantified and valued for inclusion in the economic analysis, it is important that the economist include them in the analysis in a qualitative manner and not just ignore them. Finally, items involving real resource use are split between traded and nontraded. The pathways beyond "traded" are displayed in Figure 3-3. Pathways beyond "nontraded" are split into "nontraded inputs," Figure 3-4, and "nontraded outputs," Figure 3-5.

As this section progresses, we will repeatedly return to these diagrams to illustrate how items are traced through the process to arrive at the relevant economic price. To aid in this process, Worksheet 4 was developed, which takes the impacts from the physical inputs and outputs, and prepares them for economic pricing.

Worksheet 4 lists each benefit and cost, provides a short description of the economic pricing considerations, and categorizes them as local or foreign components, or as unskilled labor. These classifications are necessary for shadow pricing foreign exchange and unskilled labor, a subject we will address later in the chapter. In addition, the worksheet includes the unit price or cost estimates derived. The contents of Worksheet 4 are the result of using the decision tree to determine how to price the item.

Worksheet 4 is also the appropriate place to enter the values of any benefits and costs arising from environmental effects. In the example presented here the only cost mentioned is loss of fishing income. If there were other quantifiable externalities, they should also be included.

Figure 3-2
Decision Tree for Determining Economic Values
Major Steps

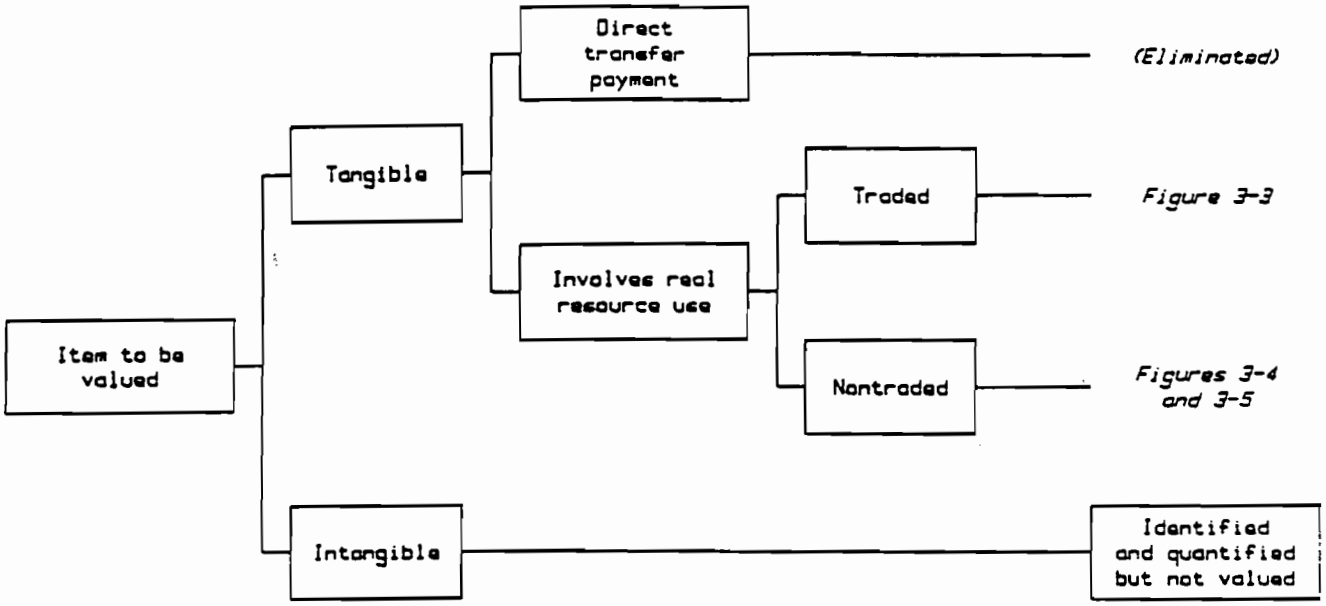


Figure 3-3
Decision Tree for Determining Economic Values
Traded Items

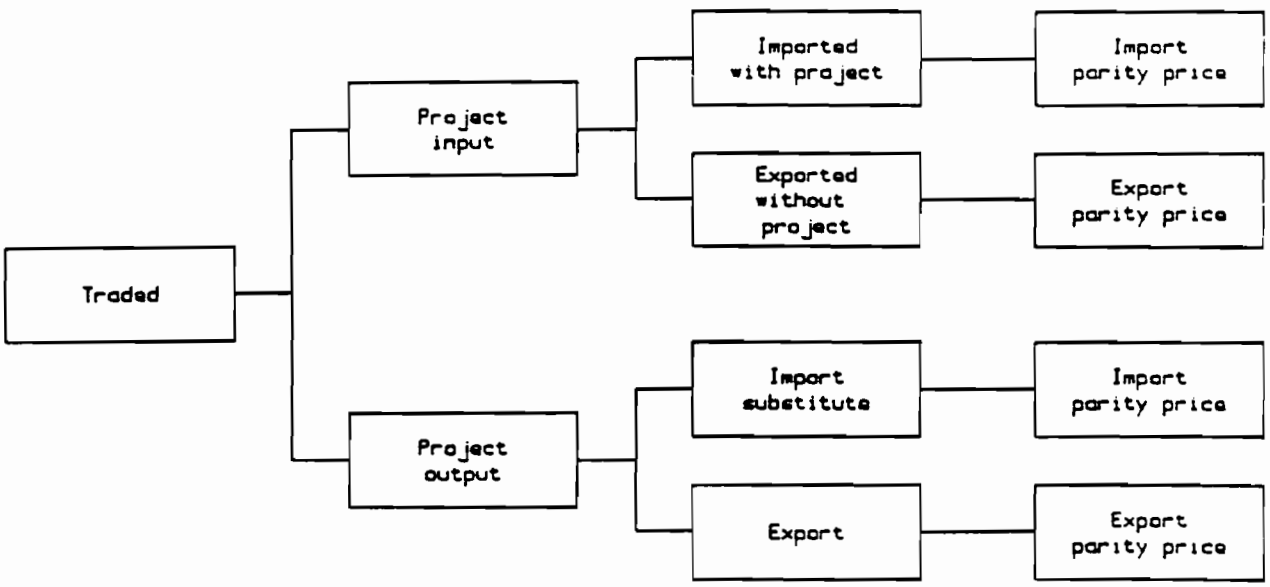


Figure 3-4
Decision Tree for Determining Economic Values
Nontraded Items - Project Input

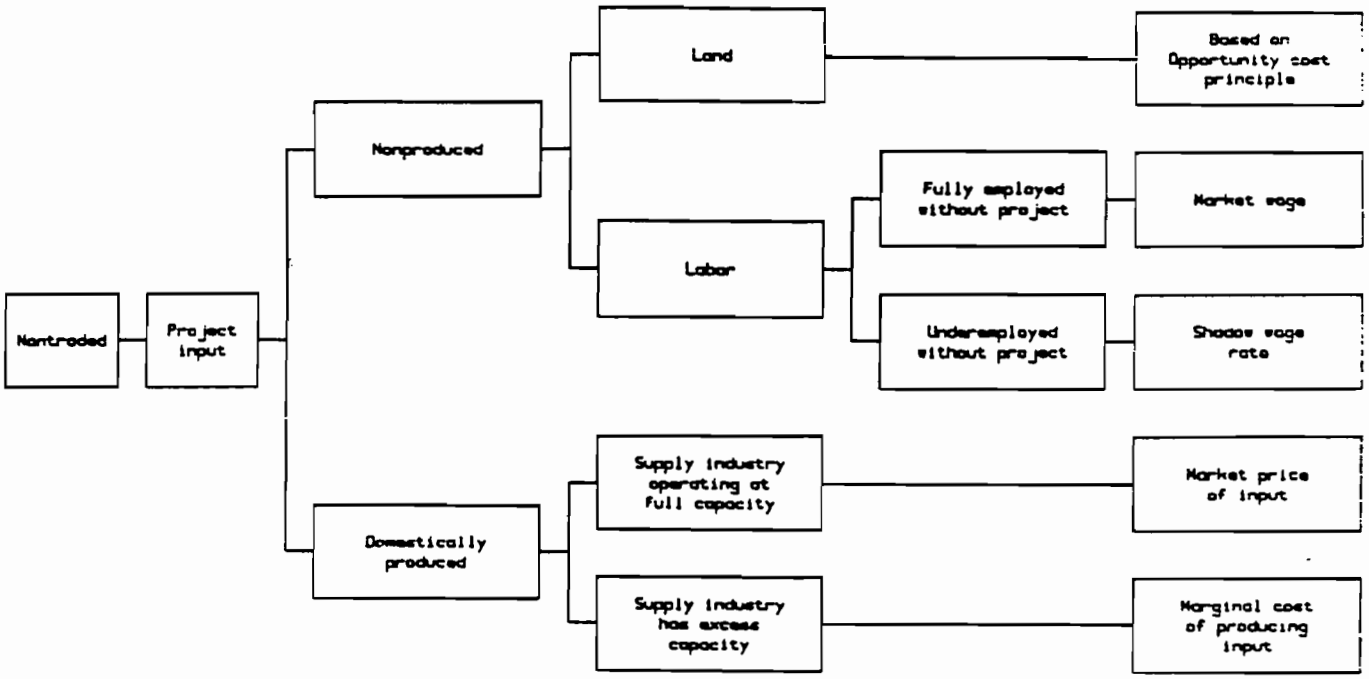
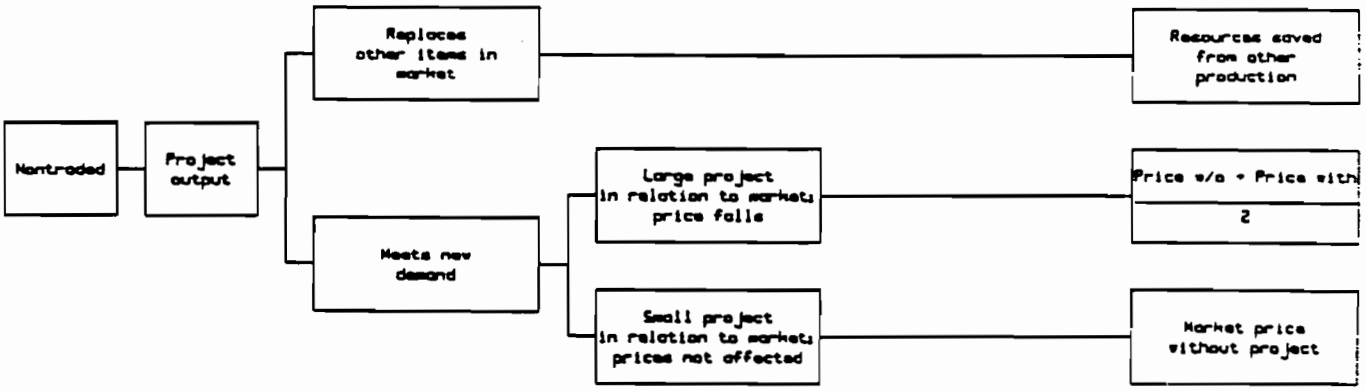


Figure 3-5
Decision Tree for Determining Economic Values
Nontraded Items - Project Output



Source: Gittinger, J. Price. "Economic Analysis of Agricultural Projects." 1982. Johns Hopkins University Press. Baltimore.

3.5.2 Traded Items

Before beginning this discussion, a few terms need to be defined. When we refer to "border price," we mean the price of a traded item at the local port. Import prices are quoted as cost-insurance-freight (c.i.f.) prices and exports are quoted as free-on-board (f.o.b.) prices. Border prices are usually the only price estimates available for traded inputs or outputs, which is why adjustments are required to get "project boundary" prices -- the price at the project site. In some cases even border prices are not available, so the economist must get prices at foreign ports and make the necessary adjustments to convert them to border prices.

Because all foreign exchange components will be adjusted by the shadow exchange rate (SER) in the economic analysis, the foreign exchange component of costs or benefits must be identified. This requires that border prices be estimated to evaluate the foreign exchange components of the project. When the project's product is made for export, the foreign exchange earnings are calculated from the f.o.b. border price. When the project uses inputs that were previously exported, the f.o.b. border price is needed to evaluate the reduction in foreign exchange. Inputs which are imported use the c.i.f. border price to evaluate their foreign exchange component. When the project's output substitutes for an imported product, the c.i.f. border price is required to evaluate the reduction in foreign exchange required for purchase of imports.

With traded items, unless administratively set, the project boundary price usually must be estimated from these border prices. The estimation involves adjusting for tariffs, subsidies, local port charges, and local transport charges to arrive at the project boundary prices. Outputs involved in import substitution and inputs which divert exports will likely have a domestic impact from a difference in transportation and handling costs. The project boundary price calculations are required to determine these domestic cost impacts. In the literature, these project boundary prices are referred to as "export" and "import parity prices." Before turning to examples of the valuation of traded inputs and outputs for the economic analysis, we must discuss export and import parity price calculations.

3.5.2.1 Import Parity Prices. Figure 3-6 displays a diagram illustrating the chain of calculations required for the economic import parity price relating to inputs and outputs. As the diagram indicates, project inputs that are imported are straightforward calculations. The case involving project outputs is more difficult and occurs when a project produces an "import substitution" product, one that will reduce imports of its competing product.

Without the import substitution project, the market price in the country is composed of the c.i.f. price plus all port, transportation, and marketing costs to get the product to the "inland" wholesale market. With the project, the economist must calculate what price the project can expect to receive for its product -- the project boundary price. Because the estimation involves calculating a "parity" price with respect to an imported product, the project boundary price, in this case, is called an import parity price. The estimation requires that all transportation costs, port fees, and other charges involved in getting the imported product to the inland wholesale market from the port be estimated as well as the transportation and other costs required to get the project's competing product from the project site to the inland market. Calculating the import parity price provides all of these estimates.

Assigning benefits using the with/without rule requires two values, (1) the c.i.f. price of the imported product for the foreign component in Worksheet 4 and, (2) the difference in local costs between the without-case, costs incurred from port to inland wholesale market, and the with-case, costs incurred from the project boundary to the inland market. This latter calculation can result in either a positive or negative benefit, depending on whether local costs are saved or lost with the project.

3.5.2.2 Export Parity Prices. Figure 3-7 illustrates the chain of calculations required for the economic export parity price. The adjustments are similar in content to the import parity price adjustments, just the direction is changed -- where we added costs, we now subtract costs. For project outputs, application of the export parity price calculation is straightforward, as the diagram shows. In the case of project inputs, the calculations are more complicated. This is the case of "diverted exports" shown in the decision tree of Figure 3-3.

For the diverted export case, the inland wholesale market price is composed of the f.o.b. border price less all port costs, transportation costs, and tariffs between the inland wholesale market and the port where the product is exported. The export parity price is the project boundary price, estimated by adding the transportation costs between the project boundary and the inland wholesale market. This is the price the project pays for the input. Assigning benefits using the with/without rule is done by calculating the difference in local costs (inland market to port and inland market to project boundary) and evaluating the foreign exchange component from the f.o.b. border price.

Figure 3-6

Import Parity Price Calculation

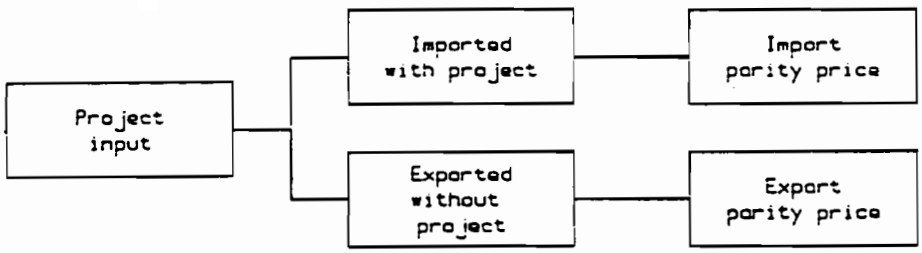
A. Inputs Imported for the Project	B. Output of the Project Substituting for Imports
1. F.o.b. price at foreign port + Insurance & freight =	1. F.o.b. price at foreign port + Insurance & freight =
2. C.i.f. price at local port + Port & transport charges =	2. C.i.f. price at local port + Port & transport charges =
3. Import parity price at project boundary, e.g. farm-gate, plant gate	3. Wholesale price at inland market - Transport costs from project to inland market =
	4. Export parity price at project boundary

Figure 3-7

Export Parity Price Calculation

A. Project Output being Exported	B. Inputs to Project Diverted from Export
1. C.i.f. price at foreign port - Insurance & freight =	1. C.i.f. price at foreign port - Insurance & freight =
2. F.o.b. price local port - Tariffs, port & transport charges =	2. F.o.b. price at local port - Tariffs, port & transport charges =
3. Export parity price at project boundary	3. Wholesale price at inland market + Transport costs from project to inland market=
	4. Export parity price at project boundary

3.5.2.3 Traded Inputs. In Figure 3-3, traded input items could be classified as either imported with the project or exported without the project. In the OSB model, chemicals are an input produced domestically and exported, thus they represent a traded item (they have impact on foreign exchange). Starting in Figure 3-2, chemicals are identified as a "tangible" with "real resource use," and "traded." From the "traded" branch, we move to Figure 3-3, where the relevant pathways are reproduced below.



Now, using Figure 3-7B, we can trace the calculations for our diverted export example. Start with the cost incurred in getting the chemicals from the wholesale market to the port. This is one million pesos for a total cost at the port (the f.o.b. price-based cost) of 52 million pesos. With the project, the cost incurred in getting the chemicals from the wholesale market to the project boundary (the OSB plant) is two million pesos for a project boundary cost of 53 million pesos. The difference in domestic costs -- one million pesos -- represents a resource cost charged to the project and is classified as the local component of total costs in Worksheet 4. These calculations, using Figure 3-7B, are shown below.

Cost Calculation for the Diverted Export Example
(In Million Pesos)

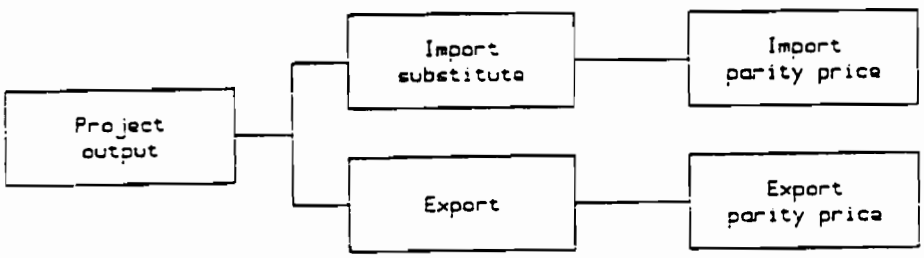
1. Cost of chemicals using f.o.b. price	+	52
2. Less transport & port charges from market to port	-	1
3. Cost at wholesale market	=	51
4. Add transport to project boundary	+	2
5. Cost at project boundary	=	53

Entries in Worksheet 4

Local component (4. - 2.)	=	1 million pesos
Foreign component	=	52 million pesos
Total Cost	=	53 million pesos

The foreign component will be adjusted with the shadow exchange rate to determine the true economic value of this cost. If the government had been imposing an export tariff on the product to generate foreign exchange earnings, this part of the f.o.b. price would be removed because it represents a direct transfer to the government.

3.5.2.4 Traded Outputs. In the OSB model, the sheathing panels fall into the "import substitution" category of Figure 3-3. We chose this example because it illustrates a development strategy used quite often in developing countries. The other branch of the "project output" path is a very straightforward case of a product being produced for the export market. The relevant portion of Figure 3-3 is reproduced below.



The sheathing panels will substitute for imported panels. Because an international market exists for this product, sheathing panels are classified as traded. The portion of Figure 3-3 reproduced above shows the relevant economic price to be the import parity price. Figure 3.6B shows how the calculation takes place. Note that if the port and transportation costs of getting the import to the wholesale market were equal to the costs of getting the OSB flooring panel to the wholesale market, the border price of the import would equal the project boundary price of the OSB flooring panel (the import parity price). Because this is unlikely, we will use costs that result in a difference. This difference is the local component of the benefit, which can be negative or positive depending on the cost differentials.

Worksheet 4

Economic Prices for Benefit and Cost Calculations

Item	Local Component	Foreign Component	Labor Component	Comments
BENEFITS				
1 Sheathing Panels Period: 3-25 yrs Units: P/KSF	50	3,500		Case of import substitution. Need import parity price.
2 Flooring Panels Period: 3-25 yrs Units: P/KSF	5,400			Output replaces domestic production.
3 Resource cost of plywood panel production. Period: 3-4 yrs Units: P/KSF	5,000			Saved resources from replacement of plywood plant.
4 Road Improvement Period: 3-25 yrs Units: pesos	123,005			Paving road from the logging operation to OSB plant reduces operating costs.
COSTS				
1 Forgone revenue from old plant Period: 3-4 yrs Units: P/KSF	5,360			Loss of revenue from plywood plant being replaced by OSB plant.
2 Wastewater Period: 2 Units: pesos	1,000,000		500,000	Estimate of cost for treatment plant.
3 Air Pollutants Period: 2-25 Units:				No estimate
4 Land Period: 1 Units: per acre	1,072,000			Purchase of land for OSB plant site. Use market price.

* See notes at end of chapter for details of the calculations.

Worksheet 4 (continued)

Economic Prices for Benefit and Cost Calculations

Item	Local Component	Foreign Component	Labor Component	Comments
Costs				
5 Buildings/ Structures Period: 1 2 Units: pesos	5,000,000 27,000,000	10,000,000	5,000,000 13,000,000	Domestically produced with foreign and unskilled labor components.
6 Equipment/ Processing Period: 2 Units: pesos	1,000,000	210,000,000		Domestically produced with foreign component.
7 Equipment/ Boiler Period: 2 Units: pesos	25,200,000	10,800,000		Domestically produced with foreign component.
8 Equipment/ Other Period: 2 Units: pesos	111,000,000		37,000,000	Domestically produced with unskilled labor component.
9 Chemicals Period: 3 4 5-25 Units: pesos	1,000,000 1,500,000 3,000,000	52,000,000 78,500,000 104,000,000		Domestically produced product that is exported. Project will divert some exports.
10 Loss of fishing income Period: 3 4 Units: pesos	59,250 87,764			Logging operations impact fishing yields during regrowth cycle.

* See notes at end of chapter for details of the calculations.

Using Figure 3.6B and starting with step 2, the following calculations illustrate the local and foreign components of this benefit. As in the previous "diverted export" example, we are use costs, not unit prices, for the project's third period output quantity (3.5 p/sqf x 30,000,000 sqf).

Cost Calculation for the Import Substitution Example
(In Million Pesos)

Cost of imported panels using c.i.f. price	105
Add port and transport charges from port to market	+ 3.9
Cost at wholesale market	= 108.9
Less transport charges to project boundary	- 2.4
Revenue at project boundary	= 106.5

Entries in Worksheet 4
After Converting back to Prices

Local component	= 50 P/KSF
Foreign component	= 3,500 P/KSF
Total revenue	= 3,550 P/KSF

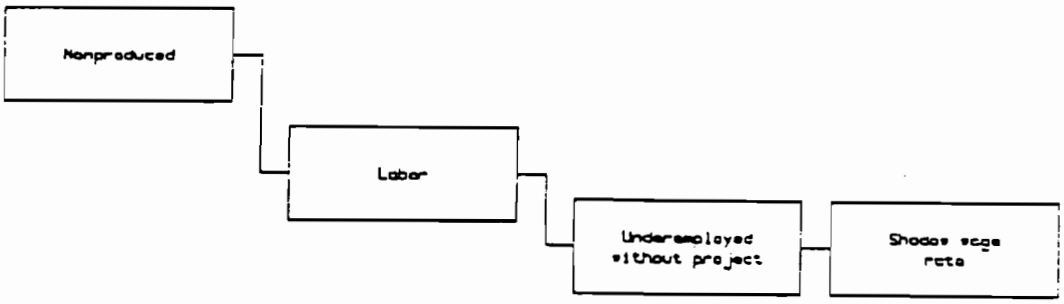
The only wrinkle in evaluating traded outputs for export is whether the market for the output will be affected enough to cause prices to fall. If this is the case, then the output should be evaluated as a marginal benefit to the economy as a whole. Forecasting such price changes due to increasing exports is a difficult task and, fortunately, rarely needed. Developing nations are usually price-takers in world markets which are large enough to absorb supplies by individual nations with no significant price changes.

3.5.3 Nontraded Inputs

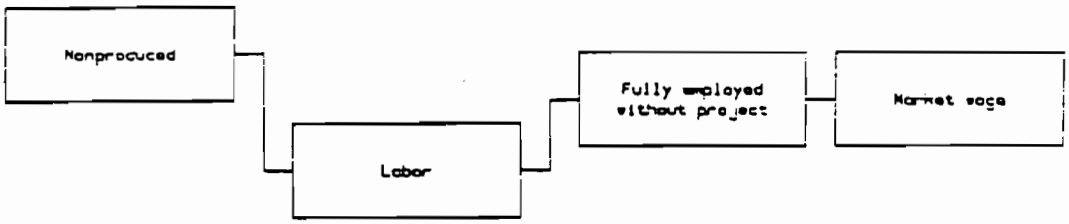
The classification of nontraded inputs is accomplished using Figure 3-4 of the decision tree. The proliferation of branches in Figure 3-4 relative to the "traded" diagram hints at more complexity in classifying these items and estimating their economic prices. The first branching divides nontraded inputs into either "nonproduced," such as land and labor, or "domestically produced," such as goods from domestic industry.

3.5.3.1 Nonproduced Inputs. In the OSB model, the plant purchases land in a competitive urban market where the market price is judged to be a good indicator of its opportunity cost. Therefore, no adjustments are necessary for the economic analysis. Unskilled labor in the OSB project, is also a small component of total costs, as is often the case in industrial projects. But, for illustrative purposes, the adjustment to unskilled labor costs will be made for the OSB example. This requires estimation of the shadow wage rate (SWR).

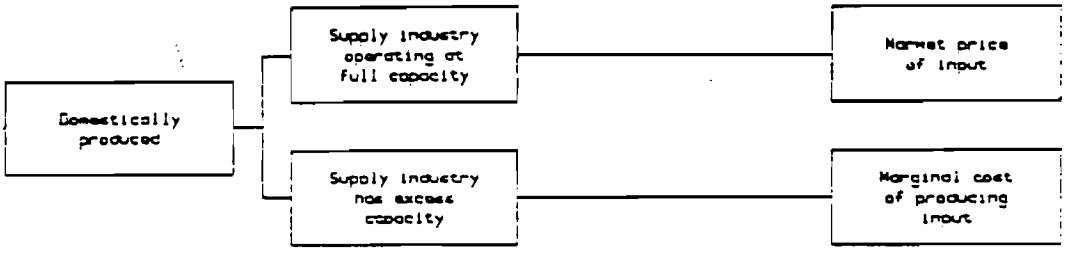
In preparation for the SWR adjustment, Worksheet 4 breaks out the unskilled labor component (under the "Labor" heading) for each cost item. The method for determining the economic cost of the unskilled labor component is found by tracing the relevant pathways in Figure 3-4 as shown below. In projects that involve construction of buildings, structures, or roads, the unskilled labor component can sometimes be obtained from the contractor's construction bid or directly from the contractor if the bid does not contain the details.



As shown below in a portion of Figure 3-4, the market wage is used for all "fully employed without project" labor. In the OSB model, all skilled labor is assumed to be a scarce resource and, therefore, skilled labor is "fully employed without project." In Worksheet 4, these costs are subsumed under the local-currency component because they require no adjustment.



3.5.3.2 Domestically Produced Inputs. The other major branch in Figure 3-4 refers to inputs purchased by the project which are domestically produced. Two situations may arise depending on the degree of excess capacity in the industry from which the inputs are purchased. The first case, when the industry is at or near full capacity, assigns the market price as the relevant economic price, after, of course, adjusting for any subsidies or other distortions that may exist.



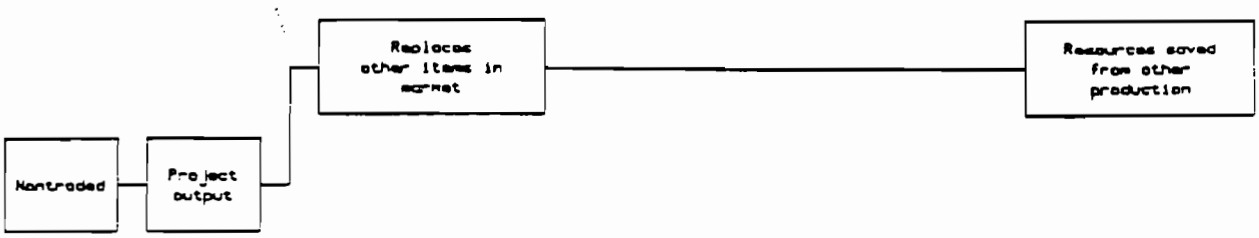
The second case arises when there is substantial excess capacity in the industry. Gittinger and others from the World Bank's Economic Development Institute advocate that market price, in this situation, over estimates the cost to the project in economic terms. The argument arises from the fact that with excess capacity, the project's demand will not require any expansion of capacity in the industry. Existing capacity can accomodate the demand and, therefore, only the marginal variable costs of production should be charged to the project. Because the market price incorporates payments on plant and equipment (short-run fixed costs), marginal variable cost would be less than the market price.

It is hard to believe that a project's demand for a single input will be great enough, in most cases, to require an expansion of capacity in industries near or at full capacity. Instead, the project's demand may add to existing demand pressures, which in the aggregate, may require future expansion of capacity. Whether the project required all of the input in the construcion phase or as a component of operating costs which would be demanded over the life of the project, would determine how easily the industry could cope with a substantial new demand.

The situation is not as clear cut as presented in the literature, and, therefore, the economist must carefully evaluate each situation before committing to making an adjustment to the market price. Given that estimation of marginal variable costs is difficult and time consuming, such an estimation is only warranted when the input is a major cost item to the project and when the industry is suffering from severe excess capacity.

3.5.4 Nontraded Outputs

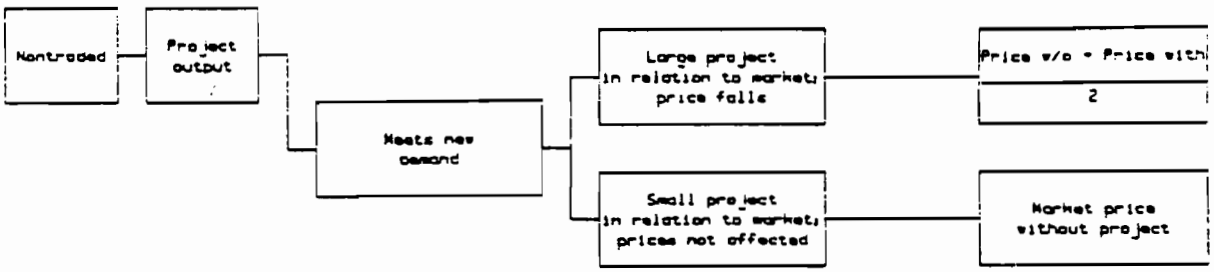
In Figure 3-5, the decision tree depicts the pathways for determining economic prices for nontraded outputs. There are two situations to consider. The first involves projects intended to replace existing production, such as when a new technology replaces an old technology for a particular industry. This branch of Figure 3-5 is shown below.



The flooring panels in the OSB model are introduced to illustrate the first situation. We assume that the country has been using softwoods (pine) for plywood construction of flooring panels and that the stands of softwoods are fast becoming depleted. Oriented strand board technology is a new technology for employing currently underutilized hardwoods to make flooring panels that directly substitute for the plywood panels. Thus we have a situation where the old technology (plywood industry) cannot adapt to the depletion of its primary input, but a new technology (OSB) is available that will produce the same product from underutilized wood resources.

In Worksheet 4, Item 3 in the benefit section lists the benefit derived by forgoing production of the plywood panels -- the direct substitution of OSB output for plywood output. This benefit is the total resource cost of producing the plywood panels -- a cost that will be avoided with OSB production. The associated cost of the forgone plywood production is then the forgone revenue, shown as Item 1 in the cost section. Therefore, even with the project, the old plant is still producing during the first four years of the project; at 100% during years 1 and 2, 50% in year 3, and 25% in year 4. The phase-out schedule of the old plant is the complement of the phase-in schedule of the OSB plant such that total supply of flooring panels does not change. (A simplifying assumption for this case).

The second situation, where project output adds to current production, is straightforward when the price of the product does not fall. The new output would have to be quite substantial to affect the current market price; but if it does, a reasonable way to evaluate the economic price is to simply average the old and new prices. This is shown in the following pathway of Figure 3-5.



The formula estimates the consumer surplus generated by the project and depends on the simplifying assumption that the demand curve is on a 45- degree angle.

3.6 With-Project Economic Benefit-Cost Flow Statement

Worksheet 5 organizes the benefit and cost estimates developed from Worksheet 4 into a format that clearly displays the local component (LC), foreign component (FC), and unskilled labor (L) components for each item and by project phase. Investment and operating costs now comprise all cost impacts identified with the project. With-project benefits are also displayed to complete the economic cash flows. The without-project benefits and costs are not displayed, but are included in Worksheet 6 which displays the project's final incremetal net benefits. All transfer items have been removed.

All prices have been evaluated for possible distortions and corrected if needed, with the exception of applying the SER and SWR to foreign currency and unskilled labor, respectively. The justification for not applying the shadow prices to factors such as labor and foreign currency items at this stage of the analysis is that these major adjustments should be presented separately so that (1) decision-makers can readily identify their effect and (2) sensitivity analysis can be performed in a straightforward manner.

Table 3-1

Quantities, Prices, and Costs for Worksheet 5

Item	Price	Quantity	Total Cost
BENEFITS:			
Sheathing panels			
Local component	50 P/KSF	60 m. sqft	3 m. pesos
Foreign component	3,500 P/KSF	60 m. sqft	210 m. pesos
Flooring panels			
Local component	5,400 P/KSF	50 m. sqft	270 m. pesos
Resource cost saved*			
Local component	5,000 P/KSF	50 m. sqft	250 m. pesos
COSTS:			
Forgone revenue*			
Local component	5,360 P/KSF	50 m. sqft	268 m. pesos
Land			
Local component	1,072,000 P/acre	30 acres	32 m. pesos

*These only appear in Worksheet 6 as without-project benefits and costs.

In cases where the economic pricing information in Worksheet 4 are displayed as unit prices instead of total costs, the quantity estimates are needed to complete the cash flows in Worksheet 5. Table 3-1 illustrates these quantities, the unit prices, and the resulting costs that appear in Worksheet 5. The quantities reflect full production amounts. For the start-up periods, multiply the total costs in Table 3-1 by 50% and 75%, respectively.

3.7 Economic Benefits and Costs Summary

Worksheet 5 displays the detailed results of the economic analysis short of the final application of the SER and SWR. Worksheet 6 will apply these adjustments; summarize the results by incorporating without-project net benefits; and present the economic internal rate of return (EIRR), the net present value (NPV), and the Benefit-Cost Ratio (BCR). Before presenting Worksheet 6, we need to discuss how to derive the SER, SWR, and another parameter needed for

Worksheet 5

With-Project Economic Benefit-Cost Flow Statement
(millions of pesos)

Phase	Construction						Start-Up						Full Operation									Terminal Value	
Output %	0%			0%			50%			75%			100%			100%			100%				
Year	1			2			3			4			5 -- 1 8			19			20 -- 2 5			25	
	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC
BENEFITS																							
Sheathing panels							1.5	105.0		2.3	158.0		3.0	210.0		3.0	210.0		3.0	210.0			
Flooring panels							135.0			203.0			270.0			270.0			270.0				
Road improvements							0.1			0.1			0.1			0.1			0.1				
Total Benefits							136.6	105.0		205.4	158.0		273.1	210.0		273.1	210.0		273.1	210.0			
COSTS																							
Lost fishing income							0.0			0.0													
Investment Costs																							
Fixed capital																							
1 Land/site preparation	32																					16.0	
2 Buildings/structures	5	10	5	27.0		13.0																0.0	
3 Equipment																							
Processing equipment				1.0	210.0																	0.0	
Boiler & fuel system				25.0	11.0																	0.0	
Other				111.0		37.0																0.0	
4 Road improvements	10			12.0																		0.0	
5 Engineering & const mgmt	20			32.0																		0.0	
6 Wastewater treatment				1.0		0.5																0.0	
Total Fixed Capital	67	10	5	209.0	221.0	50.5																16.0	
Working capital (incremental)							17.0			20.0			0.0			0.0			0.0			37.0	
Replacement capital (Boiler)							0.0			0.0			0.0			18.0			0.0				
Operating Costs																							
1 Raw materials																							
Wood							49.0			74.0			98.0			98.0			98.0				
Chemicals							1.0	52.0		2.0	78.0		3.0	104.0		3.0	104.0		3.0	104.0			
2 Labor																							
Skilled							6.6			9.9			13.2			13.2			13.2				
Unskilled									0.3			0.4			0.5			0.5			0.5		
3 Other costs							39.0			59.0			78.0			78.0			78.0				
Total Operating Costs							95.6	52.0	0.3	144.9	78.0	0.4	192.2	104.0	0.5	192.2	104.0	0.5	192.2	104.0	0.5		
Total Costs	67	10	5	209.0	221.0	50.5	112.6	52.0	0.3	164.9	78.0	0.4	192.2	104.0	0.5	210.2	104.0	0.5	192.2	104.0	0.5		
NET BENEFITS	-67	-10	-5	-209.0	-221.0	-50.5	24.0	53.0	-0.3	40.5	80.0	-0.4	80.9	106.0	-0.5	62.9	106.0	-0.5	80.9	106.0	-0.5	53.0	

discounting benefits and costs, the opportunity cost of capital (OCC). Policy dictates that A.I.D. will supply the SDR estimate for project papers.

3.7.1 The Shadow Exchange Rate

For the OSB model, we will calculate a SER using the trade-based approach discussed in Chapter 2. Because the SER/OER ratio is likely to fluctuate over time, the ratio is calculated as an average over the most recent four years for which the data exist. These calculations are as follows.

Calculation of the SER with Trade Statistics
(millions of pesos)

Year	X	Sx	M	Tm
1	2.1	.2	2.2	.43
2	2.0	.2	2.3	.56
3	2.2	.2	2.4	.61
4	1.9	.2	2.2	.43
Total	8.2	.8	9.1	2.03

$$\frac{SER}{OER} = \frac{(M+Tm) + (X+Sx)}{M + X} = \frac{9.1+2.03+8.2+.8}{9.1 + 8.2} = 1.16$$

The foreign exchange components of the analysis, already converted to domestic currency with the OER, are then multiplied by 1.16 to account for the premium on foreign exchange.

3.7.2 The Shadow Wage Rate. Assume a project will employ unskilled workers year around. The area where the project will employ labor is an agricultural region where seasonal employment is the norm. Only during harvest are most workers fully employed. The wage rate, then, for this seasonal work is a good measure of the marginal value product of unskilled labor. If this season consists of 90 days each year and there are 260 working days in the year, the rural wage can be estimated by weighting the on-season and off-season rates by their respective annual fractions to which they apply. If the on-season wage is 20 pesos a day and the off-season wage is primarily home production estimated at two pesos a day, then the rural annual average wage is,

$$\text{rural (shadow) wage} = (90/260) \times 20 + (170/260) \times 2 = 8.23 \text{ pesos}$$

This is the shadow wage rate for abundant labor in the economic analysis. As a practical matter, making adjustments for the SWR to labor costs from the financial estimates is simplified by expressing the SWR as a ratio of the shadow wage to the project wage. This

makes it easier to apply to the total labor cost components that require shadow pricing in the economic analysis. The ratio, which we will also call the SWR, is expressed as:

$$SWR = \frac{\text{shadow wage}}{\text{project wage}}$$

In the example above, if the project wage is 16.46 pesos a day, this ratio
would be,

$$SWR = 8.23/16.46 = .50$$

In the OSB example of this chapter, unskilled labor is insignificant relative to total labor costs (skilled and unskilled) and hardly worth calculating relative to total costs. This is not unusual for capital- intensive industrial projects. We will use the SWR of .50 calculated above to adjust the unskilled labor components shown in Worksheet 4.

3.7.3 Elements of the Summary Statement

The benefits and costs summary forms the basis on which the central conclusions of the economic analysis are drawn. This statement is derived from the detailed benefits cost-flow statement in Worksheet 5. Worksheet 6 incorporates the SWR and SER adjustments and records these values at the bottom of the worksheet. Worksheet 6, however, contains only those benefits and costs which are tangible (and, therefore, quantifiable in monetary terms). The intangible costs and benefits are quantified to the maximum extent possible and then discussed in the project paper. A fuller analysis of environmental costs associated with fishing and logging may well yield a number of quantifiable items that can, and should, be included in the analysis. As should be clear, unless these effects are included early in the analytical process they will tend to be overlooked and left out of the various tables and worksheets. It is the responsibility of the economist and the project analysts to see that these impacts are included.

Worksheet 6 is divided into four main sections and subdivided further according to local currency items, foreign currency items, and unskilled labor, all of which facilitate the presentation of information to the decision-makers. Across the top of the worksheet are the usual divisions in worksheet 6 project implementation, i.e., construction, start-up, full operation, and terminal value. These apply more directly to physical infrastructure-type projects, but can be made to apply to almost any project. At the bottom, the SER and SWR ratios are shown along with the investment criteria values; the economic internal rate of return (EIRR), the net present value (NPV), and the benefit-cost ratio (BCR). The investment criteria are discussed next.

Worksheet 6

Economic Benefits and Costs Summary
(millions of pesos)

Phase	Construction		Start-Up		Full Operation			Terminal
Output %	0%	0%	50%	75%	100%	100%	100%	Value
Year	1	2	3	4	5 -- 18	19	20 -- 25	25
WITH-PROJECT								
BENEFITS								
Local Component			136.6	205.3	273.1	273.1	273.1	53.0
Foreign Component			105.0	158.0	210.0	210.0	210.0	
Total Benefits			241.6	363.3	483.1	483.1	483.1	53.0
COSTS								
Local Component	67.0	209.0	112.6	164.4	192.2	210.2	192.2	
Foreign Component	10.0	221.0	52.0	78.0	104.0	104.0	104.0	
Labor Component	5.0	50.5	0.3	0.4	0.5	0.5	0.5	
Total Costs	82.0	480.5	164.9	242.8	296.7	314.7	296.7	
NET BENEFITS	-82.0	-480.5	76.7	120.5	186.4	168.4	186.4	53.0
WITHOUT-PROJECT								
BENEFITS								
Local Component			134.0	201.0	268.0	268.0	268.0	
COSTS								
Local Component			125.0	188.0	250.0	250.0	250.0	
NET BENEFITS			9.0	13.0	18.0	18.0	18.0	
INCREMENTAL NET BENEFITS								
Local Component	-67.0	-209.0	15.0	27.9	62.9	44.9	62.9	53.0
Foreign Component	-10.0	-221.0	53.0	80.0	106.0	106.0	106.0	
Labor Component	-5.0	-50.5	-0.3	-0.4	-0.5	-0.5	-0.5	
Total	-82.0	-480.5	67.7	107.5	168.4	150.4	168.4	53.0
INCREMENTAL NET BENEFITS WITH SHADOW PRICING								
Local Component	-67.0	-209.0	15.0	27.9	62.9	44.9	62.9	53.0
Foreign Component (SER)	-11.6	-256.4	61.5	92.8	123.0	123.0	123.0	
Labor Component (SWR)	-2.5	-25.3	-0.2	-0.2	-0.3	-0.3	-0.3	
Total	-81.1	-490.6	76.3	120.5	185.6	167.6	185.6	53.0

Net Present Value at 12% Discount Rate = 560 million pesos Shadow Exchange Rate (SER) = 1.16
Economic Internal Rate of Return = 25.6% Shadow Wage Rate (SWR) = 0.5
Discounted Benefit-Cost Ratio = 1.15

3.8 Using Sensitivity Analysis

Project appraisal is, essentially, a forecasting exercise. While the initial costs of a project can usually be determined with a fair degree of confidence, the operating costs and benefits associated with the life of the project are considerably less certain. From the discussion on estimating the SER and SWR, it should be clear that they will be subject to uncertainty as well.

Sensitivity analysis is a procedure designed to investigate the impact of uncertainty on the investment criteria (NPV and EIRR) by systematically recalculating their values after changing one estimate at a time, by a given amount. Because any of the dozens of estimates required in economic analysis can have a significant impact on NPV or EIRR, this piece of the analysis can be quite involved. Therefore, the first step in sensitivity analysis is to establish which estimates require analysis, in order to minimize the required effort. For example, any estimate that is felt to be within 10% of the true value probably will not require analysis, for a 10% change in either direction will not significantly affect the NPV or EIRR, unless the value is a large contributor to costs or benefits.

There are two questions surrounding each estimate to be evaluated. The first is how much does one vary the estimate, in percentage terms, and second, how much does the variation change NPV or EIRR? The second question also poses the problem of how much change is cause for concern. A procedure called switching-value analysis can provide insights into these questions and organize the sensitivity analysis. A switching value is defined as the percentage change required in an estimate to either (1) set the NPV to zero or (2) set the EIRR equal to the OCC. Because the discount rate used to calculate the NPV is the OCC, these conditions are clearly equivalent.

The alternative to using switching values requires an estimate of the probability distribution around each estimate to be analyzed. The probability distribution defines the spread around the estimated value (taken to be the mean). This allows one to estimate various ranges around the estimate and associate these ranges with probabilities. Clearly, it would be difficult to specify these distributions in practice. The switching-value method does not eliminate the need for these distributions because it doesn't address the probability of the estimated switching values, but it does provide a consistent method for determining what values result in the minimum acceptable NPV and EIRR.

The OSB model will be used to illustrate the calculation of switching values. The SER, SWR, price of OSB panels, and total investment costs will be used as candidates for sensitivity analysis. Because the switching-value calculations require an iterative procedure, the calculations won't be illustrated here (see

Section 3.10.4 in Chapter Notes). However, the results of the analysis are displayed in Table 3-2 for inspection.

Inspection of Table 3-2 shows the project is quite insensitive to a change in total investment, but the project is sensitive to changes in the price of OSB panels. A 19% variation in the price estimate could occur over the life of the project. This indicates a need to reduce uncertainty in the price forecast of OSB panels. Because the SER affects both benefits and costs, a change in the SER has a very small effect on net benefits, therefore, no reasonable value causes NPV to become zero. The SWR has no effect because unskilled labor is a very small component of costs in this project.

Table 3-2

Switching Values for the OSB Model

Variable	Switching Value
1. Price of OSB panels	-19%
2. Total Investment	+221%
3. The SWR	none
4. The SER	none

3.9 Using Risk Analysis

The role of risk analysis is to ultimately estimate the expected value of the NPV or EIRR. This means associating probabilities with the range of estimates for the key variables identified in the sensitivity analysis. Risk analysis helps to identify what strategies will reduce the risk of project failure. This can mean investing more time and resources into improving cost estimates, to reduce uncertainty in the estimates and, therefore, reduce the risk of project failure.

Risk assessment also covers the evaluation of physical risks that can have disastrous results on the project if steps are not taken to alleviate potential problems. These are usually technical problems associated with the construction phase. The technical staff must develop alternative construction techniques to eliminate or reduce the risks.

The estimation of the expected value of NPV or EIRR based on probability distributions of the key variables involves resources that are unlikely to be available to the project, therefore, the need to even attempt their estimation should first be assessed.

There are three conditions to apply in this assessment. That is, there is no need for quantification of risk if: (1) the NPV or EIRR for the project are so high that the expected value of either is likely to exceed the minimum requirements; (2) only one or two variables significantly affect the NPV or EIRR such that simple sensitivity analysis will point to required actions for reducing the risk of failure; and (3) the required changes to project planning that will reduce risks or ensure against special hazards are obvious.

3.10 Notes to Chapter 3

3.10.1 Calculations for the Magnitude Analysis Example

The annual benefit and cost estimates are shown below assuming that construction costs are evenly split over the two-year construction period, that there is a two-year, start-up phase at 50% of full capacity, and a 25 year planning horizon.

Phase	Construction		Start up		Full Production
Output	0%	0%	50%	50%	100%
Period	1	2	3	4	5-25
Benefits	0	0	257.5	257.5	515
Costs	262	262	153	153	306
Net Benefit	-262	-262	104.5	104.5	209

Net Present Value @ 12% = 702.4 million pesos
Internal Rate of Return = 28%

3.10.2 Notes on Calculations in Worksheet 4

Benefits:

(1) Sheathing panels:

Calculate the economic import parity price as follows. First calculate the wholesale selling price of the imported item --

- o take c.i.f. price of 175 US$/KSF,
- o convert to pesos using official exchange rate to get 3,500 P/KSF,
- o add the port and transportation-to-wholesale-market costs equal to 130 P/KSF,
- o arrive at 3,630 P/KSF.

Subtract from this the transport costs from the plant to the wholesale market of 80 P/KSF and arrive at the financial import parity price of 3,550 P/KSF. This price comprises both the local and foreign currency components for benefits assignment. The foreign component is the c.i.f. price of 3,500 P/KSF. The local component is the difference in transport costs (130-80) or 50 P/KSF, the remainder of the 3,550 parity price.

(2) Flooring panels:

This product will replace existing local plywood production. The owners of this plant will retire a plywood plant and the OSB flooring panels will substitute for the forgone production from the retiring plywood plant. The project boundary price is the applicable price in this situation. Calculate it by,

- o taking the current market price for plywood flooring panels at 5,480 P/KSF,
- o and subtracting the cost for transport, marketing, and distribution which is 80 P/KSF,
- o to arrive at the project boundary price of 5,400 P/KSF.

(3) Resource cost of plywood production:

The old plant is retired after the two-year start-up phase of the OSB plat. The benefit of saved resources is based on partial operation of the plant for these years. The calculation requires an estimate of the value of the resources (materials and labor input) required in producing the plywood panels at the old plant; the fixed capital of the plant can be considered to have no residual value and therefore does not enter into the calculations. This cost, in P/KSF, is then multiplied times the output of the OSB plant during the start-up phase to arrive at total displaced resource cost. For this example, we have assumed a resource cost of 5,000 P/KSF.

(4) Road improvements:

This is an example of a benefit that does not appear in the financial accounts. The project must pave 10 miles of rough gravel road between the logging area and the OSB plant. This benefits current traffic (trucks and buses) by lowering operating costs an estimated 50%. Both normal traffic (the without-project/traffic) and diverted traffic from other gravel roads must be evaluated.

Calculation of Savings per Day

	Savings (peso/mile)	# Vehicles (per day)	Miles of Road	Savings (per day)
Trucks (normal)	.30	100	10	300
Trucks (diverted)	.30	10	10	30
Buses (normal)	.20	10	10	20
Buses (diverted)	.20	2	10	4
Total				354 P/day

Savings for the year would depend on the number of days in a year each vehicle category operates. For simplicity assume that both trucks and buses average six days a week or 312 days for a total annual saving of 110,448 pesos. To complete the analysis for all years a traffic forecast is necessary for estimating the growth in traffic, and it is likely that the savings figures will increase over time due to congestion without the project. These complications are not included in this example.

Costs:

(1) Forgone revenue from old plant:

The plant being replaced represents a loss to national income, or a cost in the project analysis. The boundary price at the old plant is calculated by subtracting the transportation costs to the wholesale market. The old plant is farther from the wholesale market so transportation costs are 120 P/KSF, resulting in a forgone revenue price of 5,360 P/KSF -- the market price of plywood panels, 5,480 P/KSF, minus 120 P/KSF.

(2) Wastewater:

Although a waste treatment plant for the plant's effluents may be considered in some cases during the financial analysis, in this example we assume that it was not. Only during the economic analysis, where the environmental considerations are traced to their impacts, is the wastewater problem addressed. The economist obtains estimates of the cost of constructing the treatment plant from a local contractor at 1.5 million pesos. The contractor also provides an estimate of the unskilled labor component at 33% of total cost.

(3) Air pollutants:

Not included in the financial analysis. Project team decides that they cannot quantify intangible cost associated with degradation in air quality.

(4) Land:

The land for the plant site is near an urban center, and land prices are believed to be good indicators of true opportunity cost of the land. The market price from the financial analysis can be used for the economic analysis.

(5) Buildings/structures:

Financial price for building is 60 million pesos with a component of imported steel equal to 10 million pesos converted at the official exchange rate, and an unskilled labor component of 18 million pesos. These values will be adjusted by their respective shadow prices later in the analysis.

(6) Equipment-processing:

The price used in the financial analysis was 232 million pesos. It consists of a c.i.f. price of 10,500,000 US$, which converted at the official exchange rate is 210 million pesos, plus a 10% import duty of 21 million pesos and local port charges and transportation costs totalling 1 million pesos. For the economic analysis, the project boundary price (or import parity price) is calculated by simply omitting the import duty (transfer). To derive the local and foreign components, split the c.i.f. cost (foreign component) from the transport and port charges (local component). The foreign exchange component will be adjusted by the shadow exchange rate later.

(7) Equipment-boiler:

The boiler and fuel system are locally produced. The raw materials used in manufacture of the boiler have a foreign component equal to 30% of the total cost or (36 million pesos x .30) 10.8 million pesos. This component will be adjusted later with the shadow exchange rate.

(8) Equipment-other:

This cost item consists of auxiliary equipment, electrical wiring, and installation. The unskilled labor component is estimated to be 25% of the total cost of this item.

(9) Chemicals:

This input represents a diverted export. The local chemical plant currently exports most of its output, but the project demands will require a large fraction of these exports. The chemical industry may expand in future to meet increased demand but this is too uncertain to allow for in these calculations. The loss to the country from diverting exports to the project is the foreign exchange forgone. This is the f.o.b. price of the diverted export. The export parity price is calculated by,

- starting with the costs at the local port based on the f.o.b. price equal to 52 million pesos,
- subtracting the port charges and transportation charges to inland market equal to 1 million pesos,
- to arrive at inland market price of 51 million pesos.
- add to this the transportation costs from inland market to project boundary of 2 million pesos,
- to arrive at 53 million pesos for the export parity price.

The foreign and local components are the f.o.b. costs of 52 million pesos and the difference in market to point-of-sale costs between the project purchase and the export of (2 million - 1 million) 1 million pesos, respectively. Years 4 and 5 are computed similarly.

(10) Loss of fishing:

Fishing output has been declining for some time due to development upstream and overfishing. The soil erosion from the initial logging operation is estimated to affect fishing for only the start-up phase, before seedlings in logged areas can retard further erosion. Impact is estimated as a 1% loss of fish harvest. Fish harvest is currently declining at 1.5% per year and current yield is estimated at 6 million. Calculations for the start-up years are as follows.

- Current income is 6 million pesos, and losses are already 1.5% per annum, which means that by year 3 (first start-up year) the yield is expected to be 6 million x (.9853) or 5,734,030.
- Logging operations affect fish yield in this year by reducing it another 1.0%. The loss is then 5,734,030 x (.01) = 57,340.
- The second year losses are calculated by further reducing the yield by the 1.5% and then the 1.0% due to the project. This equals 5,734,030 x (.985) x (.01) or 56,480.

Both of these amounts are negligible with respect to the size of total project costs, therefore they will be dropped from the remainder of the analysis.

3.10.3 Investment Criteria for Comparing Costs and Benefits

For the reasons given in Chapter 2, only discounting investment criteria will be discussed in this section. These are the Net Present Values (NPV), Economic Internal Rate of Return (EIRR), and the discounted Benefit/Cost Ratio (BCR) which will be applied to the OSB model for illustration.

3.10.3.1 Net Present Value

The net-present-value approach, as its name implies, converts the stream of future net benefits (or costs, in the case of cost-effective analysis) to their present equivalent value. The discount rate used on future flows of net benefits is the opportunity cost of capital (OCC) discussed earlier.

A simple example illustrates the impact of the timing of benefits on the value of NPV. Assume that in one case the project will produce all of its benefits in the second year of the project, where the first year represents the construction phase. Alternatively, let the benefits be spread out over years two through four. For the former case, the NPV is calculated as

$$NPV = \frac{-20}{(1+.10)^1} + \frac{30}{(1+.10)^2} = 6.61 \text{ million pesos}$$

where,

Investment	=	20 million pesos
Net benefits in year two	=	30 million pesos
The OCC	=	10%

For the latter case, where the 30 million pesos of net benefits are spread evenly over three years, the calculation is as follows:

$$NPV = \frac{-20}{(1+.10)^1} + \frac{10}{(1+.10)^2} + \frac{10}{(1+.10)^3} + \frac{10}{(1+.10)^4}$$

$$= 4.43 \text{ million pesos}$$

Spreading the return over the three-year period, therefore, has a large impact on the present value of the project. Long delays in benefits result in less attractive returns when discounted to their present value.

In general, the NPV can be expressed as shown in eq. 1:

$$NPV = \sum_{t=1}^{T} \frac{NB_t}{(1 + r)^t} \qquad (1)$$

where,

NB = net benefits (negative or positive) in each time period,
t = specific time period, usually a year,
T = total time periods in the project (where t=1 is the first period),
r = opportunity cost of capital.

If the NPV is greater than zero, then the project is deemed acceptable, all other things being equal. The NPV for the OSB model appears at the bottom of Worksheet 6.

3.10.3.2 Economic Internal Rate of Return

If the "r" value is increased in the example above, it is clear that the NPV will decrease. At some level of "r," the NPV will be zero. This "r," which produces an NPV of zero, is known as the economic internal rate of return, or EIRR. If the EIRR is greater than the opportunity cost of capital then, all other things being equal, the project is deemed acceptable.

If the net benefit stream changes sign more than once over the project horizon, then it is possible that two or more EIRRs will exist. This happens when the net benefits, after turning positive following a series of initial negative values (construction phase and possibly the start-up phase), again turn negative in future years. This may happen if the margin of net benefits is quite small and the project enters a few years involving replacement expenditures that increase costs more than the existing margin. Also, if net benefit streams are uniformily positive or negative then the EIRR does not exist. The former situation is extremely rare; the latter case, constant negative net benefits, is clearly undesirable from any perspective.

Calculating the EIRR does involve an iterative procedure, which is quite tedious without a computer. Searching for the discount rate that equates the present value of benefits and costs can only be solved by repeatedly testing discount rates until something close to equality (their difference is close to zero) is achieved. For a detailed discussion of the mathematics of calculating the internal rate of return, see Gittinger, pages 332-338.

3.10.3.3 The Benefit-Cost Ratio

Another traditional measure of project worth is the benefit-cost ratio. It is sometimes used without discounting but for many reasons undiscounted methods should not be used in project economic analysis (see Section 2.10.1). The ratio is related to the NPV because it also uses the present value of the benefit stream and the present value of the cost stream. Where the NPV uses the

difference in these two quantities, the benefit-cost ratio (BCR) divides the two -- discounted benefits by discounted costs. The discount rate to use in these calculations is the OCC as it is in the NPV calculations. The BCR can easily be shown from rearranging equation 1.

$$NPV = \sum \frac{NB_t}{(1 + r)^t} = \sum \frac{(B - C)_t}{(1 + r)^t} = \sum \frac{B_t}{(1 + r)^t} - \sum \frac{C_t}{(1 + r)^t}$$

$$BCR = \left[\sum \frac{B_t}{(1 + r)^t}\right] / \left[\sum \frac{C_t}{(1 + r)^t}\right] \qquad (2)$$

where

B_t = benefits in t,
C_t = costs in t,

and all other variables are as defined for equation 1.

Because the BCR is a ratio it has no units. For example, a value of 1.30 means the the present value of benefits exceeds the present value of costs by 30%. In general, when the BCR exceeds one the project is deemed acceptable, which simply means the analysis results in a positive net present value.

The BCR measure has one drawback -- it is sensitive to the classification of impacts. That is, some impacts can validly be assigned as either positive costs or negative benefits (or vice versa), which influences the ratio that makes up the BCR. This is easily seen by examining equation 2. If you add 10 to the numerator you get a different ratio value. If, instead you add the benefit of 10 as a negative cost (- 10) to the denominator, you get another ratio value. This problem would not affect the NPV because assignment to either the benefit side or cost side would leave the difference unchanged.

CHAPTER 4

SECTOR-SPECIFIC GUIDANCE

This chapter contains sector-specific guidance concerning five primary sectors for which most project economic analysis is performed in developing countries. Problems in benefit and cost calculations that the economist is likely to encounter in these sectors are discussed and practical methods from the literature are presented as a possible means for solving these problems. Some introductory information about the specifics of each sector is also offered and, in two instances, case studies are presented to illustrate the methods to employ. In the other sectors, these calculation methods are presented in abbreviated or digested form. Specific examples that encompass the techniques being discussed are used to illustrate the methodology.

The chapter begins with the agricultural sector, followed by transportation. The health, financial, and education/training sectors complete the presentation. The agricultural sector discusses irrigation, processing, and research and development projects, and presents a case study concerning an agricultural research and development project. The transportation sector looks at projects involving railways, shipping, and road development, with an emphasis on the latter. The health sector discussion concentrates on the difficulties in assessing the benefits of health care projects, with numerical examples illustrating the techniques most often used. The financial sector discussion is concerned with the appraisal of lines of credit and equity investment, with a illustrative case study. The last section presents the specifics of conducting economic analysis for training and education programs and the difficulties encountered in assessing benefits for these kinds of projects.

4.1 The Agricultural Sector

The agricultural sector is increasingly appreciated as a keystone of economic development. The importation of foodstuffs represents significant demands on scarce foreign exchange and, typically, the largest component of the population is engaged in small-farm, near-subsistence agricultural production. It is also true that low-income consumers often spend 80% of their income on food, consequently, any reduction in food costs benefits them directly.

In the past, projects have tended toward infrastructural and processing-capability development, but today they are more often

aimed at the farm itself -- a micro approach as opposed to a macro approach. As such, these projects must recognize the social and cultural aspects as well as the climate, soil, financial, and economic characteristics of the agricultural sector. Probably the most common type of project in this category relates to developing, supporting, and encouraging the utilization of techniques that increase agricultural productivity at the farm level. Since the project in applied agricultural research and development is essential for increasing farm productivity, it was chosen for a case study. Other types of projects discussed in this section include irrigation, storage, marketing, and processing projects.

The approach for giving guidance in developing analyses of such agricultural sector projects is (1) to describe the general characteristics of these project types and (2) to describe the predominant costs and benefits usually associated with each and (3) to show how they may best be assigned values. Recommendations on data sources and special analytical techniques will be provided as available.

There is one element common to all agricultural development projects that cannot be overemphasized. This is the complex interdependence between natural, technological, social, cultural, financial, and economic forces which, if not properly accounted for, can doom even the most perfectly conceived projects to eventual failure. All projects are complex but agricultural projects have the added burdens of adjusting to uncertain natural processes and to social environments steeped in history and tradition. The economist must, therefore, work closely as a member of an interdisciplinary team to ensure that economic issues are incorporated into the technical decision-making process throughout the various project phases. For example, if an irrigation project is to open up new lands for cultivation, the cropping patterns and crop varieties should be determined jointly by economic and agronomic considerations.

Agricultural development projects also frequently have an effect on the environment. The very elements of such projects -- water management, land shaping, and application of chemicals among others -- can create unintended environmental effects, both on-site and off-site. As discussed earlier, the analyst has to keep these effects in mind and should include them in the economic analysis to the extent possible.

4.1.1 Irrigation Projects

Irrigation projects were the predominant types in the earlier days of large-scale economic development efforts. It remains true that dependable water supplies are crucial to providing acceptable agricultural productivity. Where nature is not reliable or generous in water supply, agricultural improvements may proceed only if appropriate irrigation projects are undertaken.

Irrigation projects take diverse forms, but most contain elements which could be classified as:

- water supply may be surface water (streams and rivers) or groundwater (wells or springs). Groundwater sources may either be from granular or fissured structures, with recharge rates generally higher in granular structures. All of these sources vary with rainfall in the drainage basin or recharge area and with withdrawals by other developments. Surface waters tend to exhibit the greatest variability and are therefore often coupled with reservoir creation to smooth out this variability. In some cases, both ground and surface waters are used conjunctively.

- water distribution and drainage include such items as canals, pumping, weirs, drainage works, piping, diversion structures, and holding basins.

- land development includes the designation of the area to be irrigated, the cropping pattern to be used, the description of required topographical changes (such as leveling, or roads necessary for the operation and maintenance of the farms, or the water distribution system), and descriptions of present and projected land use in the project area.

- settlement includes basic housing and the construction of schools, health care facilities, and community facilities for recreation and commerce required by the influx of population. Institutions must also be established within these settlements to manage and maintain the irrigation facilities, assess and collect fees, and maintain the community facilities.

- agricultural services are usually included because irrigation-fed agriculture often differs from the regimen to which the farmers are accustomed. Also, farmers moving to newly opened lands may be landless or unemployed and may lack the experience in farm management necessary for success. For these reasons, extension service support is often critically important to the success of the irrigation project. This support is in addition to the normal support of input supply provided in all agricultural areas. These service components should include guidance regarding the efficient use of

irrigation water and the application of inputs specific to the optimal cropping patterns consistent with the irrigation project's capacity. The support should also contain provisions for marketing the produce.

4.1.1.1 Assessing Costs of Irrigation Projects. Costs in irrigation projects can be divided into physical goods, labor, and land. Rarely are difficulties encountered in defining the physical goods required for an irrigation project. These would consist of the materials used in the construction of dams (in surface water projects) or wells (in groundwater projects), canals, pumping stations, drainage works, land levelling, roads, and settlements. Other physical goods are required for the operation and maintenance of the irrigation facilities, such as power for pumps, equipment for dredging, and replacement of pumps and liners. These are in addition to the physical goods associated with operation of the farms themselves, such as seed, fertilizer, fuel, herbicides, pesticides, and planting and harvesting equipment. These goods associated with the farm-level operation are normally segregated to allow for the analysis of the project's financial impact on the farmers -- a critical element in the success of a project but not a part of the economic appraisal. Good discussions of this aspect of agricultural projects can be found in Gittinger (1982, pp. 65-183) and Brown (1979).

The quantities and market prices for the physical goods required in the construction and operation of the irrigation systems are also generally easy to define, although in some instances the technical evaluations underestimate the maintenance required. The determination of shadow prices for these items usually involves straight-forward applications of the principles presented in Chapters 2 and 3. Determination of quantities of farm-level physical goods presents a more difficult problem as they are related to the cropping patterns and intensities as well as soil types and water applications from both natural and irrigation sources. Once the quantities of farm-level physical inputs are determined, they also are generally shadow priced in a straight-forward manner. As the determination of these quantities is a product of the benefits analysis, they will be discussed in Section 4.1.1.2.

Normally, the labor requirements are easily determined for the construction phase of irrigation projects with shadow prices applied to the abundant labor quantity, i.e., the shadow wage rate. The farm-level labor is more complex because of the presence of substantial family labor which may be difficult to identify and assign values to. A technique recommended by Gittinger (1982, pp 138-139) is to prepare farm budgets comparing the with-project situation and the without-project situation. Using the technique would only require that off-farm income forgone and hired labor costs be specified. The price to be used for the off-farm income forgone and hired labor costs would be the shadow wage rate calculated with seasonal labor demands incorporated.

The determination of land costs in irrigation projects is accomplished in a fashion similar to family labor costs in that the opportunity costs are implicitly considered when the with/without framework is applied to farm budgets. This occurs because the opportunity cost of the land to the project is the production forgone in its previous (i.e, without-project) use. To include a separate land cost would constitute double counting. When the land is to be purchased for the project, the economic cost would still be its opportunity cost, and it is best estimated from including the previous use in the without-project situation regardless of the purchase price. The exception to this simplification is when the land is not being put to its best use without the project. For example, if the land has a productive potential but is fallow because of an institutional impediment, then the opportunity cost is the potential production forgone, not the actual, which, in this case, would be zero.

When the farmer is renting, the temptation would be to use the rent as the cost of the land. This would not be correct, even when the rents are determined in an economically perfect market. Again, casting the project in a with/without framework implicitly incorporates the opportunity cost of the land. Including rent as well would be double counting.

Regardless of the source of the water, there are potential opportunity costs to its use in the proposed project and they must be considered. If the project is part of a flood control project, then the opportunity cost would have negative components, and should be considered as a benefit. If, however, downstream water users will be denied adequate water, then their loss must be considered as a cost to the project.

Groundwater sources present a more difficult opportunity cost estimation problem because less is known about aquifer behavior. Any potential decline in the water table due to the project should be investigated to the maximum extent possible. This is most important in instances of water mining, i.e., where recharge rates are very low. In surface water irrigation, the water table may actually be raised with potential deleterious effects to productivity of lower-lying lands within or surrounding the project site.

Important potential aspects of the water supply elements of irrigation projects are the short- and long-term environmental effects which may include mitigation costs. The potential environmental impacts of dams, especially, are multitudinous, although groundwater projects may also have significant impacts, such as saltwater intrusion into the aquifer. Therefore,

environmental costs (or benefits) of the proposed project need to be assessed and included. For the surface water developments these costs are often due to changes in water quantity and/or quality downstream. As indicated earlier, it is best to start with those impacts that have direct productivity effects. These may include such effects as changed drinking water quality (due to agricultural chemicals), impacts on fisheries, or changed coastal environment.

4.1.1.2 Assessing Irrigation Project Benefits

The physical output of an irrigation project is water applied to land. It is normally measured, therefore, as hectares irrigated which, by themselves, have no benefits. The benefits are determined by the impact transmission mechanism by which irrigated hectares are combined with other inputs to improve agricultural production. This improvement can be either increased quantities, improved quality, more profitable varieties, or improved timing.

The determination of cropping patterns and cultivation regimens to achieve these improvements may be simple or complex depending on the options available and the project analysis resources available. A simple program would, for example, rely on past traditions with slight modification. A complex program would include an analysis incorporating both economic and technical considerations to "optimize" resource allocations to the irrigated area. A complete explanation of these complex techniques is beyond the scope of this discussion, but, in general, they follow a linear programming framework. This framework specifies an objective function to be maximized subject to the technical constraints (as mathematical equations) of the irrigated area. The more sophisticated linear programming models also include risk and uncertainty factors. A relatively simple application of this technique can be found in Cline (1973) and Valdes (1979, pp. 11-26), with more complex applications in Duloy (1984).

Regardless of the methodology used in determining the requisite regimens, there will usually occur differences in the various sections irrigated based on soil conditions, topography, available access, etc. Brown (1979) recommends the use of farm models for each of these areas, cautioning that they must "reflect what each group of farmers is likely to do, not what the analyst would like them to do" (p. 7). These models must therefore explicitly present the assumptions of farmer behavior within the context of recommended cropping patterns and cultivation regimens. Many technical assumptions regarding weather conditions, projected yields, and quality of produce must also be made in order to estimate the value of output from the farms. These models will also provide the economist with the farm-level physical goods inputs discussed in Section 4.1.1.1.

Another important consideration is the timing of benefits. Irrigation projects, aside from being technically complex, often attract farmers unfamiliar with the prescribed cropping patterns and cultivation regimens. The settlement and training of the farmers takes time which must be incorporated into the time path forecasted for the realization of the benefits of the project.

Assigning values to the agricultural production resulting from the irrigation project is usually not a difficult task in that established markets are generally available to provide the economist a good starting point. The standard convention is to estimate the prices at the farm gate, though it should be emphasized that this may not be the same as the price actually received by the farmer. Rather "farm gate" refers to the convention of not including transportation costs of outputs from the farm to the various markets. This convention is largely one of convenience because of the difficulties associated with predicting the final markets' locale and the attendant transportation costs. This is not to say, however, that transportation costs are irrelevant. Rather, the farm-gate price at a distant farm would be lower than a nearby farm, if the markets are operating properly.

Unfortunately, markets determining farm-gate prices are often decidedly not operating properly. When the government imposes administered prices, they will inevitably contain elements of either subsidies or taxes which must be removed. If the output is for export or is an import substitute, then the world markets can supply prices which can be reasonably adjusted to the farm gate, i.e., export and import parity prices. When the output is not traded, then a choice must be made between using world prices (which may be difficult to adjust to the farm gate), or adjusting the existing prices to eliminate taxes and subsidies. Only experience and judgment can determine the best course in a particular situation; when in doubt, do both.

Other benefits commonly associated with irrigation projects relate to the services provided to the new farmers such as housing and community and commercial services. These are generally minor contributions to the overall project benefits, but should be included as values to the maximum extent possible.

4.1.1.3 Sensitivity Analyses of Irrigation Projects. The agricultural sector presents special problems because of the large influences from uncertain climatological conditions and the assumptions which must be made in projecting yields. These uncertainties should be investigated to determine which influences bear heavily on the project outcome. As a minimum, alternative yield and price assumptions must be tested, with the quality of the analysis increasing if the alternative yields can be related to

specific likely ranges of factors which determine the yields, such as farmer behavior, weather conditions, and varieties selected for cultivation. When the supply of farm-level inputs is in question (such as preferred seed, fertilizer, etc.), their potential lack should also be investigated through sensitivity analysis, however, exact technical data on impacts may not be available. Unless the lands are already populated and there is substantial experience with irrigation systems in the area, the timing of benefit realization should also be tested.

4.1.2 Processing Projects

Agricultural processing projects are a means available to developing nations to increase the value added of what is often their largest export industry. Processing projects also provide additional stability in the revenues generated because prices of processed agricultural products typically experience less volatility than nonprocessed products. Storage projects, often necessary in conjunction with processing, serve to smooth the seasonality of agricultural product sales thus contributing to stability in the agricultural sector. The marketing aspects of processing and/or storage projects can guide project developers in filling the most advantageous niche in national or international markets. These types of projects are discussed below as different aspects of a processing project, although they could conceivably be separate projects under certain circumstances. A marketing project could be beneficial in isolation. A storage project could be beneficial without processing, but not without marketing input. A processing project must contain all three aspects.

4.1.2.1 The Marketing Component. Marketing projects are conducted to increase the efficiency of a distribution channel or to find new, generally foreign, markets. If new markets are sought, marketing projects may be for new products, expanded production of old products, or more lucrative uses for existing production of old products. When expansions or new products are involved, the raw materials markets must be included in the analysis as well.

When discussing marketing projects, it is important to distinguish a marketing research project from marketing projects in general. Marketing research is limited to gathering information whereas a comprehensive marketing project also includes elements which implement changes resulting from the information gathered during marketing research. Marketing research is therefore a component of a marketing project.

The information gathered at the research phase would involve both consumers and competitors. The consumer information would include all information relating to demand for the good, such as numbers of consumers, their location and characteristics (such as age, sex, and income), and their tastes and preferences. If the

product is an intermediate one, i.e., is consumed by industry as a raw material, then the demand characteristics would include technical specifications. In either case, the annual pattern of demand and growth characteristics would also be included. The competitor information gathered would encompass identification of direct competitors and substitute product suppliers, their location, and capacities. The price information gathered would include annual patterns and projections.

Of equal importance would be an analysis of the distribution channels used to bring the products to market or supply raw materials. The key elements of the distribution channel analysis would include its efficiency, its capacity, its dependability, and its timeliness. Improvements in the distribution channels can reduce waste, transportation and handling costs, and uncertainties related to deliveries. For example, if a distribution system has a bottleneck, then a marketing project can identify it and develop solutions to relieve it.

4.1.2.2 The Storage Component. The purpose of storage is to ameliorate one of the greatest complications of agricultural produce, its seasonality. Crops and livestock are produced for maximum output given natural conditions which may coincide throughout the nation. The imbalance this produces between supply and demand could be eliminated if storage were infinitely flexible and costless; unfortunately, it is both rigid and costly. It is especially costly because of the perishability and fragility of many agricultural products. These problems often can be reduced through processing, such as canning. Storage projects are therefore often part of a processing project.

The basic problem in designing a storage project is one of inventory control. The objective is to provide the optimal storage capacity at each location at minimum cost. When storage is combined with processing, there occur the added complications of optimizing the split between storage of the raw materials and the storage of finished or semifinished produce. The methods of inventory control theory and practice are clearly beyond the scope of this guidance document, but should be within the capabilities of the project design team. The assumptions used by the team should be presented along with such information as:

- the quantities stored by type, location, and method of storage;
- the average time of storage;
- the revenues, prices, and quantities estimated to be obtained for each time period;
- assumed spoilage;

- capital costs for construction of storage facilities; and

- operating and maintenance costs for storage, including transport costs.

Ideally, the design team should consult with the project appraisal economists to develop economic costs for use in the optimization analysis of storage configuration. Any differences in the analysis conclusions between using financial costs and economic costs are then presented in the appraisal.

4.1.2.3 The Agricultural Processing Component. Often, the seasonality, perishability and fragility problems of agricultural produce can be effectively reduced by processing the agricultural output by the following methods:

1. cleaning and grading;

2. ginning, milling, cutting, and mixing;

3. cooking/pasteurizing, canning, dehydration, and freezing; and

4. chemical alteration and texturization.

In general, the higher the level of processing, the more stable is the product and the more capital and energy intensive are the processing steps, although there are many exceptions. For example, grain milling can reduce stability. Also, unlike manufacturing industries, the bulk of the produce is often reduced by further processing and the value per unit of weight is increased offering possible storage and transport cost savings. Therefore, a trade-off often exists between the level of processing (with its attendant costs) and the benefits of increased value added, reduced storage and transport costs, and reduced spoilage.

As with all agricultural sector projects, there are interdependencies that require special consideration. For example, agricultural processing projects often generate by-products, such as animal feed, which themselves can have substantial economic value if the appropriate marketing channels are available for their disposal. The economist should be aware of such possibilities when conducting the analysis because any by-products not finding a productive outlet may become a disposal problem with its attendant costs. Production scheduling is also highly interdependent and requires both close coordination with raw materials suppliers and recognition that the peak operating period may coincide with peak labor demand for harvesting. If labor for processing is scarce, it is not subject to shadow wage rates below that actually paid.

4.1.2.4 Assessing Costs of Processing, Storage, and Marketing Projects. The cost structure of processing projects is similar to a manufacturing concern in that there are planning and design costs, initial investment costs, replacement investment costs and operating costs. Generally, these are easily identifiable and can have economic values assigned based on the principles presented in Chapters 2 and 3. Imported items would be subject to the shadow exchange rate and abundant labor would be assessed at the shadow wage rate (SWR). Caution must be exercised, however, in applying the SWR to operations because peak operating periods often coincide with harvesting when all labor is likely to be scarce.

The investment costs are most easily identified when the entire project is incremental, i.e., does not use facilities already in existence. When existing facilities are used, their opportunity costs must be assessed in a with/without project framework which includes projecting the best alternative use for the facilities used by the project.

The raw materials used must also be assessed for potential foreign exchange impacts. For example, if the processing project uses raw materials which would have been exported without the project, i.e., diverted exports, then the correct economic price would be the export parity price described in Chapter 3.

The costs associated with the marketing aspects would contain research components and, possibly, distribution channel improvement components.These latter costs would include, for example, transportation improvements or the establishment of distribution and/or collection centers. Some costs may also be included in the operation costs if continuing marketing efforts are required.

The storage component costs would be included with the processing facility costs, even though storage facilities may be geographically separated.

It is normally not feasible to appraise the storage and marketing aspects separately in a processing project. Nor is it feasible to separate marketing from storage aspects in a storage project. While the costs would be easily separable, the benefits would not, as discussed in the following section.

4.1.2.5 Assessing Benefits of Processing, Storage, and Marketing Projects. The benefits of processing projects include the higher prices obtained from the value added by processing; increased price stability characteristic of processed, as opposed to raw, agricultural produce; and, when coupled with storage, increased revenue over the planting/harvesting cycle. These direct benefits would be reflected in the prices obtained, either domestically or

internationally, for the output of the project. Converting the financial prices to economic prices presents no special problems. Forecasting the quantity and financial prices, however, can prove quite difficult. Price projections are normally done in conjunction with the marketing component of a processing study because such projections require data on supply and demand conditions. Several techniques are available having various levels of sophistication and accuracy. The choice of technique will depend on the special conditions of the project, such as how much experience the country has in marketing the product and whether demand, supply, and prices are relatively stable or experience large fluctuations from year to year. If the country has marketing experience and the demand and price are stable, then a simple technique would serve. If the demand and price are volatile and the project will contribute a significant increase to supply, then a more sophisticated technique would be appropriate.

A good survey of the available techniques can be found in Rao (1978) and a summary in Austin (1981). Briefly, these techniques can be divided into three categories. The first contains the judgmental techniques such as the "delphi" or panel-consensus methods which rely on opinions of persons close to the relevant markets. Second are the various time-series analysis techniques ranging from free-hand projection of past trends to the Box-Jenkins autoregressive incremental moving average (ARIMA) techniques. These techniques are marginally valid if the underlying structure of supply-and-demand forces are stable. Also, if the project will represent a significant fraction of the overall market, then these techniques will not accurately reflect the impact the project will have on the market. The third, and most sophisticated category of forecasting tools are the causal models. These techniques include the multiple-regression models, simultaneous equation systems, and the input/output models.

If the product is new to the marketplace, then methods incorporating the product's life-cycle process should be investigated. A good overview of this process in international trade flows can be found in Wells (1972). Briefly, new products often reflect a common pattern following introduction. The early time periods are characterized by low sales, followed by periods where sales grow rapidly until the growth levels off or possibly declines. The time in each of these phases varies with the product, the availability of substitutes, and the competitive conditions of the market.

Any improvements to the distribution channels (as a result of the marketing component) or inventory control (as a result of storage improvements) would be reflected in the value added at the processing level if the savings are passed through to the processing plant with lower raw materials costs. If some of these benefits

accrue to farmers or middlemen in the distribution channel then they must be estimated as well. In any case, some of the marketing and storage benefits would be contained in the processing benefits, and it is rarely possible to separate these different benefits.

The benefits of a storage project by itself are related to (1) the increased revenues received by selling the agricultural output during off-peak marketing periods, (2) the reduction of spoilage due to proper storage facilities, and (3) the net revenues from increased marketing if additional agricultural production is marketable as a result of the project. Should this increased agricultural output result from other planned projects, then there arises difficulty in allocating the benefits to one particular project. The best solution would be to draw the project boundaries so that the agricultural output increase and the increased marketing as a result of the storage project are considered as one project. All of the costs and benefits from both aspects would be appraised simultaneously. If, however, the increased agricultural output is the result of past projects, i.e., their costs are sunk, then all of the increased benefits could be properly attributed to the storage project. The same rules would apply to a storage project in combination with a processing project.

4.1.3 Agricultural Research and Development

Less developed countries generally direct their agricultural research-and-development (R&D) programs toward immediate and practical goals where basic research consists of testing techniques and plant and animal strains (developed elsewhere) for use by their own farmers. Typically, the improvements to agricultural output from R&D follow four steps. First, through literature reviews a concept (or method) is found having potential applicability in a given country or region. Then follows investigation under laboratory conditions at the bench-scale level. If the concept still appears applicable, then on-farm demonstrations are conducted to develop expertise, to uncover potential problems, and to reduce actual and perceived uncertainty. Fourth, the refined concept is presented to regional farmers for their use along with training and any additional inputs necessary to ensure its success. Because the benefits to agricultural research and development are realized at the implementation stage -- which also is the most complex from a cultural, social, economic, managerial, and technical point of view -- this sector-specific guidance will concentrate on this phase.

Agricultural R&D efforts can be directed to any of several goals. The most common is the enhancement of land productivity but the improvement of output quality, conservation or reduction of inputs, reduced input costs, improvements to input quality, or reduction of spoilage and wastage may also be goals applied to both food and nonfood products.

The role of R&D in the agricultural sector has expanded dramatically over the last two decades, yielding large increases in productivity, especially in cereal grains. Initially, great success stories made it sound easy to double or even triple agricultural outputs simply by planting better seeds. It has since been found that the situation is considerably more complex. For example, new varieties, although more productive, have sometimes met with consumer resistance. At the farm level, new strains sometimes have required a restructuring of inputs perceived as risky by the farmers. To be effective, the development and dissemination of new techniques and technologies must be considered as part of the total agricultural package which fits into the existing structure rather than replaces it.

4.1.3.1 Costs. In comparison to other types of projects, agricultural R&D projects have a relatively low initial capital investment cost but a large recurrent operating cost component. Initial costs would generally consist of a central laboratory, field laboratories, training facilities, equipment, supplies, labor, and vehicles. The largest of the recurrent operating costs is wages and salaries. Also, there are costs related to maintenance of the structures constructed and to supplies for supporting the continual R&D effort.

4.1.3.2 Benefits. The benefits of R&D efforts are many but, in general, the only one which can be quantified and valued is the increase to agricultural productivity. Estimating this benefit involves many factors, some of which may be highly uncertain. Two areas of uncertainty predominate -- the average increase to productivity obtained by farmers and the rate of penetration of the innovation.

Increases to productivity can only be estimated after specific crops and where they will be introduced are identified. While this appears to be putting the cart before the horse, in that this is precisely the information sought in a R&D project, experiences with R&D efforts in developed nations strongly suggest that an initial feasibility analysis of potential opportunities greatly increases the chances for success. Given that the majority of R&D in developing nations is applications oriented, then it is reasonable to expect that previous experiences with potential crops or cultivation regimens will exist. These, then, can be modified to the extent possible, to fit the new application and estimates of the areas applicable can be made from agricultural surveys. It is not sufficient to simply accept experiences in other countries as directly applicable unless there are great similarities in soil, climate, input availability and cost, and existing farming practices. A technique available to assist in this process is the systematic commodity/resource analysis and development (SCRAD) framework applied in Jordan (AID, 1985). This framework considers the input supply situation as well as the markets for the output in identifying candidate crops.

The projected crops, cropping patterns, locations, and results will be extremely tentative at this stage of developing an R&D capability, but their specification provides a focus for research efforts and provides a baseline against which results can be measured.

Penetration rates have received considerable research both inside and outside the context of developing nations. Despite this research, the specification of a precise penetration rate for a particular project can prove a significant task in itself. The basic problem is that several of the important determinants of penetration rates are very difficult to quantify. In general, it has been found that a sigmoid, or S-shaped function, such as the logistic function, can best describe the behavior of innovation penetration. In other words, in the early time periods penetration is low but at some point penetration becomes rapid and then slows down once again so that it never reaches 100%. The general form of a simple sigmoid function would be the logistic function expressed as:

$$P = \frac{1}{1 + \exp(a-bt)} \qquad (1)$$

where:

P = proportion of farm land using the innovation

a = intercept term

b = slope term

t = time from introduction of the innovation

exp = exponential "e"

This function can be expressed in linear terms for estimation purposes as:

$$\ln\left[\frac{1-P}{P}\right] = a - bt \qquad (2)$$

While this equation can be estimated using regression techniques, it is rare that historical data for a project similar enough to the project under analysis will be available. An alternative and somewhat ad hoc approach would be to use equation (1) directly and noting that when (a-bt) equals zero, the proportion (P) will be .50, i.e, 50% of the farm land will have adopted the

innovation. If a reasonable value for the time it will take for half the farmland in the project area to adopt the innovation can be estimated from discussions with other project team members or previous experiences with similar projects, and an estimate of the proportion of farmland utilizing the innovation at the beginning of the planning horizon can be estimated, then equation (1) can be completely specified as it will reduce to two equations with two unknowns. For example, if half of the farmland is expected to adopt the innovation in eight years, and 5% of the farmland is estimated to have adopted the innovation at the beginning of the 25-year project planning horizon, then the following relationships would obtain:

$$a = b \times 8 \quad \text{(from } a - bt = 0 \text{ at } p = .5 \text{ and } t = 8\text{)} \qquad (3)$$

and, using equation (2) for t=1 and P=.05, yields,

$$\ln(1-.05/.05) = a - b \qquad (4)$$

Substituting "8b" for "a" from (3) above and performing indicated calculations yields,

$$2.9444 = 8b - b \qquad (5)$$

Solving for "b" yields b = .42063 and substituting this in (3) above yields a = 3.3651. Substituting values for "a" and "b" into equation (1) yields,

$$P = \frac{1}{1 + \exp(3.3651 - .42063\ t)} \qquad (6)$$

Equation (6) can then be used to estimate the proportion of farmland adopting the innovation for each year of the project planning period. For example, the penetration in year 10 would be .70, and in year 20 it would be .99. The estimation of the parameters used to specify the logistic function should be based on such factors as the distribution of land area suitable for the innovation, the interest farmers have expressed in the innovation, the degree of change presented by the innovation, and other project-specific factors rather than off-the-cuff "guesstimates" by agronomists on the project team.

Where a process or item is completely new to an area, it would seem logical to give the initial adoption level a value of zero. The logistic function, however, never has a value of zero, so an initial level close to zero must be chosen. How close to zero this initial value is has implications for the overall shape of the function, thus alternative values should be chosen to produce a reasonable time path for adoption.

There are many factors which can affect the shape of the penetration curve. Research in developing nations has provided some general relationships which can assist in judging the reasonableness of the results obtained by equation (6). Some of the more germane points can be summarized as follows relating to farm size:

- High fixed-cost innovations penetrate slower than those with lower fixed costs, with small farms adopting such techniques more slowly than large farms.

- Innovations which are scale-neutral are also adopted at a slower rate initially by small farms, but these modest operations often catch up in later periods.

- Although larger farms may adopt an innovation more quickly, they tend to utilize the adoption on a smaller proportion of their holdings.

Other important factors which affect the penetration rate are the perceived risk(s) associated with the innovation and the expected increment to profitability. Higher risks, of course, decrease the penetration rate and higher profits increase it. Other factors are less a function of the innovation itself than of the management of the project. Labor supply, for example, has been seen to be a detriment to penetration if the innovation is labor intensive and the labor demands of the innovation correspond to times of peak labor demand for other purposes. Lack of adequate credit and information can also reduce the penetration rate, as can inadequate supply of complementary inputs, such as fertilizers and seeds. The effect of tenancy structure is not clear. Some researchers argue that inadequate incentives in restrictive tenancy structures retard innovation adoption; others can find no such evidence.

Other benefits to R&D projects are more difficult to quantify and value than increases to agricultural output, but should be considered to the maximum extent possible. These may include dynamic elements associated with establishment of a credible agricultural extension service able to provide farmers information on further innovations as they become available.

C.1 Case Study: Appraisal of an Agricultural Research and Development Project

This case is intended to demonstrate an approach to appraising an agricultural R&D project for the fictitious nation of Corla. As a demonstration, it includes elements in a simplified form with many issues common to this type of project ignored if they are mechanical, rather than analytical. This is to reduce the complexity so that issues peculiar to agricultural R&D and development can be highlighted.

C.1.1 Project Definition

The government of Corla has recently completed a survey of the conditions in the agricultural sector to determine areas of potential improvement. Improvements in the agricultural sector are critical to the overall development efforts because of the large proportion of the nation (75%) involved in predominantly subsistence agriculture. Also, the low agricultural productivity results in the need for substantial food imports utilizing scarce foreign exchange.

The survey revealed large areas of land not being cultivated because the native varieties do not survive the dry periods common in the growing season. The agronomists on the survey team have conducted literature reviews and have found several drought-resistant strains of grain which may allow these lands to be productive and improve the productivity of lands now under cultivation. The cultivation regimens required, however, will require testing before release to the farmers. It was therefore recommended that a R&D effort be initiated to screen potential varieties and determine the optimum cultivation regimen for local conditions and the availability and cost of the required inputs.

The research program would have several phases. The first would concentrate on bench-scale tests of many crop varieties followed with field-testing of the most promising. The final phase would consist of extension services to the local farmers providing both the technical instructions and the required inputs. The literature reviews indicated that two of the varieties had been successful in soil and climate conditions very similar to some locations in Corla. These varieties would receive the top priority, and it was anticipated that they would be ready for field-testing early in the program to be followed by other varieties according to how closely previous conditions matched those found in Corla.

The survey found consistent soil characteristics throughout Corla in two climate zones -- the dry and the drier. To appraise the proposed program, two suitable, proven varieties were analyzed for adoption. One variety, a strain of dwarf wheat, would be applicable for the dry climate zone. The drier zone was found to be suitable for a drought-resistant variety of corn. The documented experiences in other locales were very similar to the situation in the dry zone where a variety of wheat is now being grown. The research into the corn variety encompassed similar climate conditions but dissimilar soils.

The program would be designed to exist in perpetuity, but, for the purposes of this appraisal, a planning horizon of 20 years is adopted. During this period, the entire area under present cultivation will be affected and a portion of the noncultivated, drier region affected. For the sake of simplicity, no alternatives are investigated.

The physical inputs and outputs are given on Worksheet 1, divided between the three phases, i.e., research facilities construction, research field stations, and extension services, with this latter phase divided between farm and nonfarm. It is assumed that the central research station will be constructed in the first year, the field stations in the second, and the extension services facilities in the third. Lagging the construction times will enable the results of the central station evaluation of the corn and wheat strains to be completed sufficiently so that the field stations can begin trials upon completion of their own construction, which can then have results ready for the extension services dissemination program beginning in the fourth year.

C.1.2 Preparing the Financial Cost-Flow Statement

The financial cost flows are determined separately for the farm and nonfarm portions of the project. The farm costs are prepared on a farm-budget basis with the with/without cases incorporated in the two farm models. The nonfarm costs are all incremental and have no with/without effects outside the project boundaries to be considered.

The two farm models applicable are, first, the wheat variety introduced into existing wheat cultivation areas in the dry climate zone, and the corn variety introduced into the drier zone where no cultivation is now taking place. These farm budgets are presented on Worksheets 2a and 2b for the wheat and corn varieties, respectively. The economic benefits of the project are based on total output, which includes that amount of output consumed by the household. In Worksheet 1, incremental outputs are shown for wheat and corn which reflect total output inclusive of home consumption. In Worksheets 2a and 2b, the amount of home consumption is shown separately from the amount of output to be marketed.

The financial cost flows are presented on Worksheet 2 for the investment, nonfarm, and farm-level costs. The farm-level costs are based on the inputs required per hectare for the crops under study and on the estimated adoption rates for the two crops. The estimated hectares adopting the new varieties are shown at the top of Worksheet 2 as they form the basis for the farm-level costs. The details of the adoption rates used will be discussed in Section C.1.3, but, in general, the wheat variety is expected to be ready for dissemination in year 4 while the corn is expected to take an additional two years for introduction in year 6.

Worksheet 1

Listing of Primary Physical Inputs and Outputs

Item	Initial Quantity Estimates Quantity	Units
Investment Costs		
Central Research Facility	250	thousand pesos
Research Field Laboratories	300	thousand pesos
Extension Service Facilities	200	thousand pesos
Research Equipment	150	thousand pesos
Operating Costs-Research Facilities		
Central Research Facility		
Skilled Labor	10	persons/yr
Unskilled Labor	10	persons/yr
Equipment Maintenance	25	thousand pesos/yr
Building Maintenance	15	thousand pesos/yr
Research Supplies	10	thousand pesos/yr
Research Field Laboratories		
Skilled Labor	20	persons/yr
Unskilled Labor	60	persons/yr
Equipment Maintenance	10	thousand pesos/yr
Building Maintenance	10	thousand pesos/yr
Research Supplies	5	thousand pesos/yr
Extension Service Facilities		
Skilled Labor	25	persons/yr
Unskilled Labor	20	persons/yr
Equipment Maintenance	15	thousand pesos/yr
Building Maintenance	10	thousand pesos/yr
Supplies	10	thousand pesos/yr
Incremental Operating Costs - Farms		
Zone 1 (wheat/dry)		
Fertilizer/Pesticide/Herbicide	50	Pesos/yr/ha
Seed	60	Pesos/yr/ha
Implements	5	Pesos/yr/ha
Animals	0	Pesos/yr/ha
Land	20,000	Hectares
Zone 2 (corn/drier)		
Fertilizer/Pesticide/Herbicide	50	Pesos/yr/ha
Seed	35	Pesos/yr/ha
Implements	45	Pesos/yr/ha
Animals	10	Pesos/yr/ha
Land	40,000	Hectares
Incremental Outputs		
Wheat	10	Bushels/Hectare
Corn	30	Bushels/Hectare

Worksheet 2
Financial Cost-Flow Summary
(thousands of Pesos)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Hectares Wheat	0	0	0	20	33	54	88	143	233	379	613	985	1565	2441	3709	5431	7582	10000	12418	14569
Corn	0	0	0	0	0	35	51	74	107	155	224	323	466	672	965	1382	1971	2791	3919	5435
Investment Costs																				
Central Research Facility	250																			
Research Field Laboratories		300																		
Extension Service Facilities			200																	
Research Equipment	100	50																		
Total Investment Costs	350	350	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating Costs - Research Facilities																				
Central Research Facility																				
Skilled Labor		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Unskilled Labor		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Equipment Maintenance		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Building Maintenance		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Research Supplies		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Total		65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Research Field Laboratories																				
Skilled Labor			20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Unskilled Labor			30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Equipment Maintenance			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Building Maintenance			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Research Supplies			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Total		0	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Extension Service Facilities																				
Skilled Labor				25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Unskilled Labor				10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Equipment Maintenance				15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Building Maintenance				10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Supplies				10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Total	0	0	0	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Total Non-Farm Operating Costs	0																			
Operating Costs - Farms																				
Zone 1 (wheat/dry)																				
Fertilizer/Pesticide/Herbicide	0	0	0	1	2	3	4	7	12	19	31	49	78	122	185	272	379	500	621	728
Seed	0	0	0	1	2	3	5	9	14	23	37	59	94	146	223	326	455	600	745	874
Implements	0	0	0	0	0	0	0	1	1	2	3	5	8	12	19	27	38	50	62	73
Animals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Zone 1 Farm Costs	0	0	0	2	4	6	10	16	27	44	71	113	180	281	426	625	872	1150	1428	1675
Zone 2 (corn/drier)																				
Fertilizer/Pesticide/Herbicide	0	0	0	0	0	2	3	4	5	8	11	16	23	34	48	69	99	140	196	272
Seed	0	0	0	0	0	1	2	3	4	5	8	11	16	24	34	48	69	98	137	190
Implements	0	0	0	0	0	2	2	3	5	7	10	15	21	30	43	62	89	126	176	245
Animals	0	0	0	0	0	0	1	1	1	2	2	3	5	7	10	14	20	28	39	54
Total Zone 2 Farm Costs	0	0	0	0	0	5	7	10	15	22	31	45	65	94	135	194	276	391	549	761
Total Farm Costs	0	0	0	2	4	11	17	27	42	65	102	159	245	375	562	818	1148	1541	1977	2436
Total Costs	350	350	200	2	4	11	17	27	42	65	102	159	245	375	562	818	1148	1541	1977	2436

Worksheet 2a

Farm Budget
Model 1 - Wheat/Dry zone
(one-hectare farm)

Farm Costs	Without Adoption	With Adoption	Incremental Impact
Fertilizer/Pesticide/Herbicide	20	70	50
Seed	15	75	60
Implements	15	20	5
Animals	30	30	0
Total Costs	80	195	115
Farm Output			
Bushels per hectare sold	20	30	10
Bushels per hectare consumed	20	20	0
Total Bushels per Hectare	40	50	10
Farm Revenues @ 25 pesos per bu.	500	750	250
Net Farm Income	420	555	135

Worksheet 2b

Farm Budget
Model 2 - Corn/Drier Zone
(one-hectare farm)

Farm Costs	Without Adoption	With Adoption	Incremental Impact
Fertilizer/Pesticide/Herbicide	0	50	50
Seed	0	35	35
Implements	0	45	45
Animals	0	10	10
Total Costs	0	140	140
Farm Output			
Bushels per hectare sold	0	20	20
Bushels per hectare consumed	0	10	10
Total Bushels per Hectare	0	30	30
Farm Revenues @12 pesos per bushel	0	240	240
Net Farm Income	0	100	100

Worksheet 3

Linkages of Benefits and Costs to Inputs and Outputs

Direct Physical Outputs	Economic Analysis Considerations	B/C	Traded	Non-traded
Wheat	Output consumed domestically.	B	X	
Corn	Output consumed domestically as feed.	B		X
Direct Physical Inputs				
Cent Res Facility	Domestic construction	C		X
Res Field Lab.	Domestic construction	C		X
Ext Serv Facilities	Domestic construction	C		X
Res Equipment	Imported	C	X	
Skilled Labor	Competitive market	C		X
Unskilled Labor	Shadow pricing	C		X
Equip Maintenance	Foreign contract	C	X	
Bldg Maintenance	Domestic	C		X
Res Supplies	Imported	C	X	
Fert/Pest/Herbicide	Imported	C	X	
Seed	Imported for 5-years	C	X	X
Implements	Domestically Produced	C		X
Animals	Domestic	C		X
Land	At opportunity cost	C		X

Worksheet 4

Economic Prices for Benefit and Cost Calculations

Item	Local Component	Foreign Component	Labor* Component	Comments
BENEFITS				
1 Wheat (Units: Pesos/Bushel)		25		Import Parity Price for Import Substitute
2 Corn (Units: Pesos/Bushel)	12			Domestic Price in Competitive Market
COSTS				
Investment Costs (Units: Thousand Pesos)				
1 Central Research Facility	250			Domestic Construction Costs
2 Research Field Laboratories	300			Domestic Construction Costs
3 Extension Service Facilities	200			Domestic Construction Costs
4 Research Equipment		150		Imported Equipment
Non-Farm Operating Costs (Units: Thousands Pesos/Year)				
5 Skilled Labor	55			Scarce Labor
6 Unskilled Labor			45	Abundant Labor for Half of Year
7 Equipment Maintenance		50		Performed Under Contract - Foreign
8 Building Maintenance	35			Performed By domestic Sources
9 Research Supplies		25		Imported
Farm Inputs (Units: Pesos/Hectare/Year)				
Wheat				
10 Fert/Pesticide/Herbicide		50		Imported Throughout Project
11 Seed	60	60		Imported for First Five Years of Project; Domestically Produced Thereafter
12 Implements	5			Supplied Domestically
13 Animals	0			Existing Practices Use Same Animals; Zero Incremental Costs
14 Land	0			Value Given as Production Forgone
Corn				
15 Fert/Pesticide/Herbicide		50		Imported Throughout Project
16 Seed	35	35		Imported for First Five Years of Project; Domestically Produced Thereafter
17 Implements	45			Supplied Domestically
18 Animals	10			Supplied Domestically
19 Land	0			Value Given as Production Forgone

Worksheet 5
Economic Benefit-Cost Flow Statement
(thousands of Pesos)

Year	1			2			3			4			5			6			7			8			9			10		
Hectares Wheat	0			0			0			20			33			54			88			143			233			379		
Corn	0			0			0			0			0			35			51			74			107			155		
	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L
BENEFITS																														
Wheat		0			0			0			5			8			13			22			36			58			95	
Corn	0			0			0			0			0			13			18			27			39			56		
Total Benefits	0	0	0	0	0	0	0	0	0	0	5	0	0	8	0	13	13	0	18	22	0	27	36	0	39	58	0	56	95	0
COSTS																														
Investment Costs																														
Central Research Facility	250			0			0			0			0			0			0			0			0			0		
Research Field Laboratories	0			300			0			0			0			0			0			0			0			0		
Extension Service Facilities	0			0			200			0			0			0			0			0			0			0		
Research Equipment		100			50			0			0			0			0			0			0			0			0	
Total Investment Costs	250	100	0	300	50	0	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating Costs-Research Facilities																														
Central Research Facility																														
Skilled Labor	0			10			10			10			10			10			10			10			10			10		
Unskilled Labor			0			5			5			5			5			5			5			5			5			5
Equipment Maintenance		0			25			25			25			25			25			25			25			25			25	
Building Maintenance	0			15			15			15			15			15			15			15			15			15		
Research Supplies		0			10			10			10			10			10			10			10			10			10	
Total	0	0	0	25	35	5	25	35	15	25	35	5	25	35	5	25	35	15	25	35	5	25	35	15	25	35	5	15	35	15
Research Field Laboratories																														
Skilled Labor	0			0			20			20			20			20			20			20			20			20		
Unskilled Labor			0			0			30			30			30			30			30			30			30			30
Equipment Maintenance								0			10			10			10			10			10			10			10	
Building Maintenance	0			0			10			10			10			10			10			10			10			10		
Research Supplies					0			0			5			5			5			5			5			5			5	
Total	0	0	0	0	0	0	30	0	50	30	15	30	30	15	30	30	15	50	30	15	30	30	15	50	30	15	30	10	15	50
Extension Service Facilities																														
Skilled Labor	0			0			0			25			25			25			25			25			25			25		
Unskilled Labor			0			0			0			10			10			10			10			10			10			10
Equipment Maintenance		0			0			0			15			15			15			15			15			15			15	
Building Maintenance	0			0			0			10			10			10			10			10			10			10		
Supplies		0			0			0			10			10			10			10			10			10			10	
Total	0	0	0	0	0	0	0	0	0	35	25	10	35	25	10	35	25	35	35	25	10	35	25	35	35	25	10	10	25	35
Total Non-Farm Operating Costs	0	0	0	25	35	5	55	35	65	90	75	45	90	75	45	90	75	100	90	75	45	90	75	100	90	75	45	35	75	100
Operating Costs - Farms																														
Zone 1 (wheat/dry)																														
Fertilizer/Pesticide/Herbicide		0			0			0			1			2			3			4			7			12			19	
Seed		0			0			0			1			2			3			5			9		14			23		
Implements	0			0			0			0			0			0			0			1			1			2		
Animals	0			0			0			0			0			0			0			0			0			0		
Total Zone 1 Farm Costs	0	0	0	0	0	0	0	0	0	0	2	0	0	4	0	0	6	0	0	10	0	1	16	0	15	12	0	25	19	0
Zone 2 (corn/drier)																														
Fertilizer/Pesticide/Herbicide		0			0			0			0			0			2			3			4			5			8	
Seed	0			0			0			0			0				1			2			3			4			5	
Implements	0			0			0			0			0			2			2			3			5			7		
Animals	0			0			0			0			0			0			1			1			1			2		
Total Zone 2 Farm Costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0	3	4	0	4	6	0	6	9	0	9	13	0
Total Farm Costs	0	0	0	0	0	0	0	0	0	0	2	0	0	4	0	2	9	0	3	14	0	5	22	0	21	21	0	33	32	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
Total Costs	250	100	0	325	85	5	255	35	65	90	77	45	90	79	45	92	84	100	93	89	45	95	97	100	111	96	45	68	107	100
NET BENEFITS	-250	-100	0	-325	-85	-5	-255	-35	-65	-90	-72	-45	-90	-70	-45	-79	-71	-100	-75	-67	-45	-68	-61	-100	-72	-37	-45	-12	-12	-100

Worksheet 5 (continued)
Economic Benefit-Cost Flow Statement
(thousands of Pesos)

11			12			13			14			15			16			17			18			19			20		
613			985			1565			2441			3709			5431			7582			10000			12418			14569		
224			323			466			672			965			1382			1971			2791			3919			5435		
LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L	LC	FC	L
	153			246			391			610			927			1358			1896			2500			3104			3642	
81			116			168			242			347			498			709			1005			1411			1957		
81	153		116	246	0	168	391	0	242	610	0	347	927	0	498	1358	0	709	1896	0	1005	2500	0	1411	3104	0	1957	3642	0
0			0			0			0			0			0			0			0			0			0		
0			0			0			0			0			0			0			0			0			0		
0			0			0			0			0			0			0			0			0			0		
	0			0			0			0			0			0			0			0			0			0		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10			10			10			10			10			10			10			10			10			10		
		5			5			5			5			5			5			5			5			5			5
	25			25			25			25			25			25			25			25			25			25	
15			15			15			15			15			15			15			15			15			15		
	10			10			10			10			10			10			10			10			10			10	
25	35	15	25	35	15	25	35	15	25	35	15	25	35	15	15	35	15	15	35	15	15	35	15	15	35	15	15	35	15
20			20			20			20			20			20			20			20			20			20		
		30			30			30			30			30			30			30			30			30			30
	10			10			10			10			10			10			10			10			10			10	
10			10			10			10			10			10			10			10			10			10		
	5			5			5			5			5			5			5			5			5			5	
30	15	50	30	15	50	30	15	50	30	15	50	30	15	50	10	15	50	10	15	50	10	15	50	10	15	50	10	15	50
25			25			25			25			25			25			25			25			25			25		
		10			10			10			10			10			10			10			10			10			10
	15			15			15			15			15			15			15			15			15			15	
10			10			10			10			10			10			10			10			10			10		
	10			10			10			10			10			10			10			10			10			10	
35	25	35	35	25	35	35	25	35	35	25	35	35	25	35	10	25	35	10	25	35	10	25	35	10	25	35	10	25	35
90	75	100	90	75	100	90	75	100	90	75	100	90	75	100	35	75	100	35	75	100	35	75	100	35	75	100	35	75	100
	31			49			78			122			185			272			379			500			621			728	
37			59			94			146			223			326			455			600			745			874		
3			5			8			12			19			27			38			50			62			73		
0			0			0			0			0			0			0			0			0			0		
40	31	0	64	49	0	102	78	0	159	122	0	241	185	0	353	272	0	493	379	0	650	500	0	807	621	0	947	728	0
	11			16			23			34			48			69			99			140			196			272	
8			11			16			24			34			48			69			98			137			190		
10			15			21			30			43			62			89			126			176			245		
2			3			5			7			10			14			20			28			39			54		
20	11	0	29	16	0	42	23	0	60	34	0	87	48	0	124	69	0	177	99	0	251	140	0	353	196	0	489	272	0
60	42	0	93	65	0	144	102	0	219	156	0	328	234	0	477	341	0	670	478	0	901	640	0	1160	817	0	1436	1000	0
150	117	100	183	140	100	234	177	100	309	231	100	418	309	100	512	416	100	705	553	100	936	715	100	1195	892	100	1471	1075	100
-69	36	-100	-67	106	-100	-66	215	-100	-67	380	-100	-70	618	-100	-15	942	-100	4	1343	-100	69	1785	-100	216	2213	-100	485	2567	-100

Worksheet 6
Economic Benefits and Costs Summary
(thousands of pesos)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
BENEFITS																				
Local Component	0	0	0	0	0	13	18	27	39	56	81	116	168	242	347	498	709	1005	1411	1957
Foreign Component	0	0	0	5	8	13	22	36	58	95	153	246	391	610	927	1358	1896	2500	3104	3642
Total Benefits	0	0	0	5	8	26	40	62	97	151	234	363	559	852	1275	1855	2605	3505	4515	5599
COSTS																				
Local Component	250	325	255	90	90	92	93	95	111	68	150	183	234	309	418	512	705	936	1195	1471
Foreign Component	100	85	35	77	79	84	89	97	96	107	117	140	177	231	309	416	553	715	892	1075
Labor Component	0	5	65	45	45	100	45	100	45	100	100	100	100	100	100	100	100	100	100	100
Total Costs	350	415	355	212	214	276	227	292	252	275	367	424	510	640	827	1028	1358	1751	2187	2646
INCREMENTAL NET BENEFITS																				
Local Component	-250	-325	-255	-90	-90	-79	-75	-68	-72	-12	-69	-67	-66	-67	-70	-15	4	69	216	485
Foreign Component	-100	-85	-35	-72	-70	-71	-67	-61	-37	-12	36	106	215	380	618	942	1343	1785	2213	2567
Labor Component	0	-5	-65	-45	-45	-100	-45	-100	-45	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100
Total	-350	-415	-355	-207	-206	-250	-187	-229	-155	-125	-133	-61	49	212	448	827	1247	1754	2329	2952
INCREMENTAL NET BENEFITS WITH SHADOW PRICING																				
Local Component	-250	-325	-255	-90	-90	-79	-75	-68	-72	-12	-69	-67	-66	-67	-70	-15	4	69	216	485
Foreign Component (SER)	-180	-153	-63	-130	-127	-127	-121	-110	-67	-22	66	191	386	683	1113	1696	2417	3214	3983	4621
Labor Component (SWR)	0	-5	-59	-41	-41	-90	-41	-90	-41	-90	-90	-90	-90	-90	-90	-90	-90	-90	-90	-90
Total	-430	-483	-377	-261	-257	-296	-236	-268	-180	-125	-94	34	230	526	953	1591	2331	3192	4109	5016

Net Present Value at 12.0% = 508.72
Economic Internal Rate of Return = 14%
Discounted Benefit-Cost Ratio = 1.12

Shadow Exchange Rate (SER) = 1.8
Shadow Wage Rate (SWR) = 0.9

The investment costs consist of construction of the central research facility, the research field laboratories, and the extension service facilities in years 1, 2, and 3, respectively, with operations beginning in the year following the construction of each. The research equipment is used in both the central and field facilities. Operation costs for each are given for labor (skilled and unskilled), equipment and building maintenance, and supplies. Wage rates are assumed to be 1,000 pesos per year for skilled labor and 500 pesos per year for unskilled labor.

The farm-level costs assume that no off-farm income is forgone by adopting the new varieties and no hired labor is required. The supplies (fertilizer, herbicide, and insecticide) are estimated from the results of experiences reported in the agronomic journals. The seed costs are based on world prices converted to pesos at the official exchange rate. The implement and animal costs are based upon an analysis of the traditional farming practices in Corla.

C.1.3 Identifying Costs and Benefits

The physical inputs and outputs listed on Worksheet 3 are easily classified into costs and benefits as the impact transmission mechanism is, for the most part, very straightforward. The research conducted provides alternative cultivation regimens and crops which are field-tested and fine-tuned. The extension service then provides the training, inputs, and financing necessary to present the varieties to the farmers. The behavior of the farmers in deciding whether to adopt the extension service recommendations is not certain, nor is the yield which they may achieve. In this case, the wheat varieties are very similar to those already under cultivation and they have been adopted successfully by farmers in other countries under conditions resembling those of Corla. It would therefore be expected that the adoption rates would be relatively rapid and the yield increases close to optimum, weather permitting.

The corn, however, presents a more uncertain situation in that the land to be cultivated is not now used, and the farmers would have little experience in the planting, cultivation, and harvesting of this crop. Also, the successful adoptions in other countries, while under similar climate, had markedly different soil types. This, according to the agronomists, suggests that a different cultivation regimen would be required and that yields will be somewhat uncertain. On the other hand, the potential area for corn cultivation is larger, and there exists a well-established market for the corn as feed. This would increase the welfares of both the farmers and the population consuming meat products of higher quality and lower price than is presently possible. The benefit of the corn, however, is given by its price in the feed markets. The increased standards of living brought about by the corn production are reflected by this price, so that to include them as well would be double counting.

The adoption rates for the new varieties were estimated using a logistic function to approximate the proportion of the project area adopting for each time period in the 20-year planning horizon. Because the conditions for adoption are distinctly different for the two varieties, separate functions were estimated for each. The wheat variety, because of its similarities to the existing crop and the relatively certain yield increases, is expected to be adopted somewhat faster. Persons familiar with the farmers in the area estimated that half of the land in the wheat-growing areas would be using the new varieties in about 15 years after its introduction. The corn, on the other hand, was expected to take 20 years to reach the 50% penetration level.

The yields from the two crops also differ. The current wheat production of 40 bushels per hectare is expected to rise to 50 bushels per hectare with the new variety, an incremental impact of 10 bushels per hectare at the same level of quality. The corn varieties have been estimated to produce 30 bushels which is also the incremental impact because the land, without the R&D effort, has no productive use. The corn yield, and the inputs required to achieve the yield, are more uncertain than the wheat, a factor reflected in the sensitivity analysis. The terminal values of the land were not included in this example for either wheat or corn to simplify presentation.

C.1.4 Determining Economic Prices

The economic prices for the costs and benefits associated with this project differ from the financial prices in two major areas. The first difference is the impact on foreign exchange. The research equipment and its maintenance, the research supplies, and the fertilizer/herbicide/insecticide farm-level needs will be imported throughout the planning horizon. The seed will also have to be imported for the first five years following introduction of the new varieties. After this time, domestic seed production will be in place. The imports and import substitutes would therefore be priced at the import parity price with the foreign exchange component shadow-priced at the shadow exchange rate estimated by the central planning agency at 1.8. These items represent transactions conducted at the official exchange rate, which must be adjusted by the shadow exchange rate in the economic analysis because of government policies which have resulted in distortions in the foreign exchange market.

The corn production, however, is not expected to affect foreign exchange because it will be used domestically as feed supplements. While it is true that a world market exists for corn, the remoteness of the area where the project takes place coupled with poor roads to the port of export, preclude the alternative to export the corn. Transportation costs are estimated to be prohibitively expensive. Therefore, although corn is technically tradable, under these circumstances, it is considered to be nontraded.

The second difference between financial and economic prices occurs in the labor markets. The operation and maintenance of the research facilities and the extension service will utilize labor which is abundant for a portion of the year. The central planning agency estimates the shadow wage rate for abundant labor to be .80. As this abundance is present for about half of the year, a shadow wage rate for the project was estimated to be .90.

The domestic markets provide the prices used in the construction, skilled labor, farm implements and animals on the cost side, and the corn production on the benefit side. These markets are reasonably competitive and therefore accurately reflect social costs of production (for costs) and society's willingness to pay for the output. The imported items utilize world prices adjusted to import parity prices, taking into consideration transportation and insurance costs to the Port of Corla. Local transportation costs are ignored for the sake of simplicity in this example.

The resulting economic prices are provided on Worksheet 4 with a summary of the rationale for converting financial to economic prices.

C.1.5 The Economic Benefit-Cost Flow Statement

The significance of the foreign exchange impacts and the use of abundant labor requires the isolation of foreign cost and unskilled labor components in the costs and benefits. This is accomplished on Worksheet 5. The benefits are estimated by taking the estimated hectares adopting (shown on Worksheet 2) times the average incremental yield and prices from Worksheets 2a and 2b for wheat and corn, respectively. The costs are derived by taking the financial costs from Worksheet 2 and disaggregating them according to the economic considerations described on Worksheet 4. The relevant totals are provided on Worksheet 6 as a summary to easily illustrate the impact of applying the shadow exchange rate and the shadow wage rate. Also shown on Worksheet are the net present value (NPV) and the economic internal rate of return (EIRR) for the costs and benefits provided. These are based on straightforward calculations from the incremental benefits with shadow pricing. These investment criteria indicate that the project is an acceptable one because the NPV is greater than zero when calculated using the opportunity cost of capital provided by A.I.D. of 12% and the EIRR of 14% exceeds the 12% minimum.

C.1.6 Sensitivity Analysis

The development of the incremental net benefit flows depicted on Worksheet 6 evolved from certain assumptions. A summary of these assumptions appears in Table C.1-1 along with an assessment of the conditions leading to them and the level of uncertainty associated with them. This assessment forms the basis for identifying those factors appropriately subjected to sensitivity analysis. The areas of greatest uncertainty include the corn yields, input types and quantities, corn adoption rates and year of initial dissemination, and the research equipment and supplies.

As the research equipment and supplies comprise a very small part of the overall cost structure, they are unlikely to pose a significant risk to the project. The corn output, however, is a very significant part of total cost and must be investigated thoroughly. Assuming the project will be funded if it can be shown to be economically acceptable, there is no need to investigate the sensitivity of the results to values for parameters which exceed expectations. Of importance are those factors which can cause an unacceptable economic performance. Accordingly, the following scenarios were developed:

1. Delayed dissemination of the corn variety to year 8,

2. Decreased corn yields to 20 bushels per hectare,

3. Slower corn adoption rate to 50% penetration in 25 years, rather than 20 years, and,

4. 50% increase to farm-level supplies cost for corn.

Table C.1-2 provides the results of these scenarios in terms of the impact on the NPV and the EIRR. The base-case results of 508,720 pesos NPV and 14.0% EIRR are seen to vary little in all of the more pessimistic scenarios. All retain acceptable levels for NPV and EIRR, implying that the risks associated with the uncertainties surrounding the corn variety are minimal.

Table C.1-1

Summary of Assumptions for Sensitivity Analysis

Assumption	Rationale
Wheat yield: 50 bushels per hectare	Experiences in other nations indicate yields of 40 to 60 bushels per hectare. The close similarities between those conditions and the ones found in Corla provide a high degree of certainty that an average yield of 50 bushels per hectare will be achieved.
Wheat adoption: low initial level; 50% penetration in 15 years; dissemination beginning in the fourth year of the project.	Even though the new wheat varieties are very similar to those now being used, the small-farm structure of Corla will inhibit adoption rates. The assumed rate is viewed as conservative with a high probability of achievement. As the first priority, it is expected that dissemination of the variety can begin in the first year of operation of the extension service, i.e., the fourth year of the project.
Wheat inputs: (costs on Worksheet 2a)	Both quantities and costs of farm-level inputs are very certain.
Corn yield: 30 bushels per hectare	Previous experience indicated yields of 25 to 40 bushels per hectare, but for different soil conditions. The assumed yield, although toward the lower end of the range, remains uncertain.
Corn adoption: low initial; 50% penetration in 20 years; dissemination beginning in the sixth year of project.	The relatively slow adoption rate is assumed because the variety is new to the area. This rate is uncertain, however, as is the year of initial dissemination which depends upon successful adoption of the variety.
Corn inputs: (costs on Worksheet 2b)	While the availability and costs per unit are certain, the quantities and mix are not.
Construction: completion of central research facilities, field stations, and extension service facilities in 1, 2 and 3, respectively.	Construction schedules can be met with a high degree of certainty.
Operation costs: (on Worksheet 2)	Staffing levels are certain, but some uncertainty remains in research equipment and supplies.

Table C. 1-2

Sensitivity analysis Results

	NPV (thousand pesos)	EIRR (percent)
Base Case	508.72	14.0
Delay Corn Intro to Year 8	269.78	13.1
Reduce Corn Yield to 20 Bushels per Hectare	194.17	12.8
Reduce Adoption Rate to 50% Penetration in Year 25 for Corn	249.51	13.0
Increase Corn Supplies Costs by 50%	390.76	13.6

4.2 Transportation Sector: Emphasis on Road Transport

This section discusses issues specific to performing project economic analysis for transportation projects. Projects in this sector generally involve large investments with distinct construction, start-up, and full operation phases. These projects normally entail large expenditures of foreign exchange because the components of modern transportation systems are rarely manufactured in developing countries. In addition to the initial investments requiring large amounts of foreign exchange, operating costs frequently require foreign exchange for the purchase of spare parts and fuel. Given the importance of transportation infrastructure, the large investments, the large requirements for foreign exchange, and the continuing dependence on imports to maintain and run such systems, economic appraisal of these kinds of projects is especially important.

Transportation projects involve railways, roads, airports, and port development. For maximum efficiency a country should coordinate all these pieces of the transportation infrastructure. This entails developing a transportation program for the whole country and by region if possible. Because the transportation infrastructure is a significant ingredient in economic development, and because development of a transportation network takes considerable time, the transportation program is likely to evolve slowly. Different technological advances in transportation modes will change the economics of one with respect to another, so the program must be flexible and kept current to ensure that projects have the expected benefit to the nation. The economist performing an appraisal of a transportation project should be aware of the transportation program and use its elements in performing the analysis, as appropriate.

In the early stages of economic development, transportation options for a given area are obvious. As transportation systems evolve, the choices become more complex and require better analysis based on better data. The quality of the data therefore becomes more and more important. For any given project, however, new data collection efforts are probably not feasible, so the economist must rely on existing government and private sources.

4.2.1 Assessing Economic Benefits

Project benefits in the transportation sector are difficult to value because there are almost no markets for these benefits where prices can be observed. Increases in comfort and convenience when a new road is built or a better water transport system is built are not benefits that can easily be assessed in monetary terms. In addition, benefits may affect large numbers of people over long

periods of time, such as with lower operating costs from a road improvement project, that require long-range forecasts of traffic loads. Benefits which qualify as externalities as this manual defines the term, or indirect benefits as other authors would call them, are usually involved and represent a potential for double counting.

The most important benefits to consider are as follows:

1. A reduction in operating costs for users of a new facility.

2. A reduction in operating costs for users of the existing facilities when the new facility reduces congestion for both.

3. Savings in time of travel for passengers and freight.

4. Reduction in costs associated with accidents.

5. Increased comfort and convenience for passengers.

6. Stimulation of economic growth.

These benefits are not all quantifiable in monetary terms. The reduction in operating costs is the one benefit most often addressed because it is usually possible to estimate. The increase in comfort and convenience is a benefit best left to qualification in the project paper but not quantification. In many instances, the distribution of benefits to the beneficiaries will not match the government's desires, and some structure for user charges may be appropriate to redistribute the benefits to other sections of the economy. Improvements in ports initially lower costs to shipping companies. The degree to which these savings are passed on to customers in the form of lower prices depends on the competitiveness of the industry and the pricing policy of the port authority.

4.2.1.1 Calculating Benefits from Reduced Operating Expenses. This benefit is the most easily assessed benefit in transportation projects and, fortunately, one of the most important for a new or improved facility. These benefits initially affect only the users of the transport facility, but may be passed on to the rest of the economy as the reduction in transport costs reduces total costs of production for final consumer products. In many instances, reductions in operating expenses for one mode of transportation will affect the costs of operating another mode. This comes about where there is competition between transport modes -- lowering costs for one will put pressure on competitors to also lower costs.

In assessing these benefits, there are three kinds of traffic to consider: normal, diverted, and generated or induced traffic. Each of these is discussed below.

Normal traffic: This kind of traffic defines the existing use of the facility, whether it is a road, a port, or an airport. The calculation error usually made in assessing cost reductions for normal traffic is with the inappropriate application of with/without. In transportation systems, the most common cause of increased operating expenses for users is increased congestion. If an increase in congestion is expected to occur, then the benefit of reduced operating expense will likely increase with time. Simply taking a before and after look at the congestion, without considering what will occur over the planning horizon, leads to underestimating the benefits.

Diverted traffic: When traffic is diverted from another transportation mode (e.g., railway to trucking) to the mode being improved by the project or from other routes to the project-affected routes, it is designated as diverted traffic. Benefits are calculated by comparing the difference in transport costs on the old route or mode of transport and the new facility. In doing so, the economist must use the marginal cost of shipping or traveling on the old mode instead of average costs for an accurate assessment of the true savings. If the old mode has excess capacity and the amount of diverted traffic is small in comparison to total traffic on the old mode, then average costs will significantly overestimate the cost savings. Under these conditions, marginal costs would be small.

It is important to note that when comparing different modes of transport, e.g., railway and trucking, all costs must be considered. Trucking is a door-to-door system and railway service usually requires an additional loading and unloading and a trucking component to get the freight to a final destination. Total costs include loading and unloading, storage, insurance, and breakage charges, in addition to the shipping costs.

Generated traffic: Traffic that does not exist prior to the project, but results from it is called generated or induced traffic. Assessing benefits for generated traffic is a difficult task because it entails forecasting economic growth resulting from the project. Determining what new growth can be attributed to a transportation project, or for that manner any project, is an aspect of project economic analysis that has not been well developed because of the inherent difficulties. Most of the literature recommends that this issue be dismissed in cost-benefit analysis because of these difficulties, and thus opportunities for erring.

For rural road development, the issue of economic development and generated traffic is more relevant. Roads built into an area where none existed can have substantial impact on the local economy. The reduction in travel time to a market and the access to markets allow existing cultivation to expand and new acreage to be cultivated. A.I.D. makes several observations on this aspect of rural road development in a program evaluation report (A.I.D., 1982, pp. 11-19) as summarized below. Many of its comments contrast the development of new versus upgraded roads.

1. Where competitive conditions exist, new roads led to greater reductions in transport prices, larger increases in farm-gate prices, and improved access. Reductions in transport costs for projects reviewed by the report were in the neighborhood of 60 to 90%.

2. New road projects were followed by significant increases in agricultural output. The existence of agricultural extension services, favorable land tenure policies, and transport services, led to the largest gains in production. Perishable crops saw the greatest increase because without the roads these crops were generally not marketable.

3. An increase in the use of agricultural credit was found only where the service already existed before the project or where it was made available after the project. This occurs simply because credit agents could more easily make the trip to rural areas and rural farmers could more easily and cheaply make a trip to a credit agent.

4. Rural roads generally led to increases in land values. How much the rural poor benefited from this increase depended a great deal on the government's handling of tenants' rights and the attempts by large landowners to appropriate higher values from the tenant.

5. By themselves, the rural roads did not generate an improved access to markets. It was necessary to have in place the marketing services required to gain this access, and an improved transportation industry to respond to the increased output with more and better service at lower prices.

6. The growth of local economies benefiting the poor could only be helped by rural road development if other factors existed, such as rising agricultural incomes and government policies that supported small-scale commercial and industrial enterprises.

7. Environmental impacts were not significant in most cases. Where there was an impact, it resulted in deforestation, shortened fallow periods leading to declining soil fertility, and erosion which increased siltation in nearby rivers. Where feasible, these environmental impacts should be evaluated and assessed in money terms for inclusion in project analysis.

Cost savings from reduced operating expenses are calculated on a per-unit basis for normal and diverted traffic, then total cost savings are estimated from forecasts of traffic for each type of vehicle for which a savings estimate is available. The disaggregation of savings into vehicle type is important for accurately assessing this benefit, because these costs differ significantly between vehicle types. Trucks, buses, and passenger vehicles will all have different operating cost characteristics and, therefore, different unit-cost savings. The following numerical example illustrates these points.

Example: Avoided operating costs from a road improvement.

Table 4.2-1 illustrates a traffic forecast for the 1980-2000 period (1980 is the current year) for a road targeted for improvement. The forecast is provided by type of vehicle and between normal and diverted traffic. The diverted traffic is estimated to come from alternate unpaved roads and predicted to become very congested without the project over the planning horizon.

The next information required for the calculation is average costs per vehicle-mile for each kind of vehicle and between paved (with-project) and gravel (without-project) surfaces. These data for 1980 are shown in Table 4.2-2 and would be derived from vehicle operation studies on gravel versus paved roads. The costs are net of taxes and components with import components already shadow-priced. For future years, the congestion on the affected road and the roads from where the diverted traffic will come is expected to worsen, causing operating expenses on the gravel roads to escalate.

The benefit is the difference in total costs between paved and gravel roads for each type of vehicle. To derive total avoided costs, these benefit estimates must be multiplied by the number of vehicles forecast, the length of road (in this example it is 20 miles), and 365 to convert per-day values to a year. These are shown in Table 4.2-3 for the year 1980. Future years would take into account the gravel road's escalation in operating costs from congestion, a consideration which would enlarge the benefits.

Table 4.2-1
Average Daily Traffic

Year	Trucks		Buses		Cars	
	Normal	Diverted	Normal	Diverted	Normal	Diverted
1980	220	100	40	20	90	40
1981	275	130	50	22	110	45
1982	310	150	55	24	125	50
1983	345	180	65	26	145	55
1984	485	220	78	28	174	60
1985-1990	582	250	94	30	210	65
1991-2000	700	300	112	32	250	70

Table 4.2-2
Operating Expenses
(Centavos per Vehicle-Mile)

Cost Item	Trucks		Buses		Cars	
	Paved	Gravel	Paved	Gravel	Paved	Gravel
Fuel and oil	7.1	9.1	7.2	9.1	5.9	6.5
Tire wear	7.3	16.2	7.3	16.2	1.5	3.4
Depreciation	12.1	18.0	17.4	26.0	9.5	12.2
Interest	7.0	10.0	10.0	14.0	7.0	9.0
Maintenance	9.4	14.9	13.3	21.1	2.6	3.5
Wages	4.0	5.4	4.0	5.4	-	-
Total	46.9	73.6	59.2	91.8	26.5	34.6
Benefit	26.7		32.6		8.1	

Table 4.2-3
Calculation of Total Savings

	Number	Distance	Days	Unit Savings	Total Savings
Normal Traffic:					
trucks	220	20	365	26.7	428,802
buses	40	20	365	32.6	95,192
cars	90	20	365	8.1	53,217
Subtotal					577,211
Diverted traffic:					
trucks	100	20	365	26.7	194,910
buses	20	20	365	32.6	47,596
cars	40	20	365	8.1	23,652
Subtotal					266,158
Total					843,369

The total avoided cost from both normal and diverted traffic amounts to 843,369 pesos for 1980. With unit savings and number of vehicles increasing over the planning horizon, the annual avoided cost will rise. We have also assumed in this example that operating expenses on the roads responsible for the diverted traffic without the project are the same as for the road to be improved by the project.

In other situations, the diverted traffic may come from roads where operating expenses are different and, therefore, avoided costs would be different for the diverted traffic. If the traffic is diverted from railways, say for freight, which with the project can now be shipped cheaper by truck, the avoided-cost calculations become more difficult. Marginal distribution costs of shipping freight by rail must be calculated for the without-project unit cost estimates.

4.2.1.2 Calculating Benefits from Time Savings. Improvements in transportation facilities generally reduce the time required to travel a given distance. Improving a road reduces travel time because average speeds can be increased, or widening a road will reduce time by reducing congestion and thus increasing average speed. Improvements in docking facilities can reduce the turnaround time for ships and thus reduce overall shipping time. But because of the prevalence of underemployment in developing countries, time savings have little value to a majority of the population. For this reason, it is usually recommended that this benefit not be included in the project appraisal. If the economist feels they are significant for a particular project and can at least be qualitatively assessed, then that assessment can be included. The exception to this is for aviation projects, because of the value of time savings for entrepreneurs and other professionals that make use of aviation services.

An important aspect of time savings calculations is that the value of the savings varies with respect to the total time of the trip. A one-hour savings on a two-hour trip will have a different value than a one-hour savings on a five-hour trip. If the savings allow a businessman to eliminate an overnight stay, then the value is significant to the businessman. Therefore, the value of time is not a direct function of the absolute amount of time saved and must be carefully considered in each project where it applies.

4.2.1.3 Calculating Benefits from Accident Reduction. The number of accidents per vehicle mile is high in developing countries. Reasons for this are enumerated in Adler (1971) as follows: (1) pavements are narrow and shoulders often dusty, reducing visibility significantly; (2) geometric alignment tends to be poor; (3) roads through towns are congested; (4) a large number of slow-moving

animal-driven vehicles are on the roads; (5) law enforcement is not sufficiently effective; (6) drivers are often inexperienced and reckless, especially in buses and trucks; (7) many vehicles are in poor mechanical condition; and (8) trucks tend to be overloaded. It is also important to note that a transportation project may actually increase the accident rate if increased speed is not offset by increased safety measures.

The assessment of benefits from accident reduction entails estimates of costs avoided for damage to passengers, vehicles, and freight. For non-fatal accidents, average medical costs incurred from accidents may be estimated from historical data and applied to calculate avoided costs. In developing countries, however, because medical services are not plentiful, people generally cannot afford such services unless provided by the government at highly subsidized rates. Data on these costs are unlikely to be very good, so these calculations may not be possible. Calculating the value of lives saved in avoiding fatal accidents is even more difficult and highly controversial. In this situation, it may be better to only provide estimates of number of lives saved. The assessment of benefits from avoided damage to freight and vehicles is a far more manageable calculation, and can be quite significant in monetary terms.

4.2.2 Developing Traffic Forecasts for Benefit Calculations

Transportation projects require detailed forecasts of traffic whether the system is a road network, airport, or railway service. These traffic forecasts must be based on statistics of historical use and future economic growth that will impact traffic patterns. It is one of the most difficult and important tasks in economic analysis of transportation projects.

Traffic forecasting can be divided into three main stages as outlined by Adler (1971). The first stage is an assessment of future growth in output of the goods-producing sectors of the economy: agriculture, mining, and manufacturing, as well as the consumption of raw materials and intermediate goods by these sectors, domestic and imported. Population growth by location is also required as part of the overall growth picture for the economy.

The second stage requires that these outputs and population data be translated into traffic volume by origin and destination. Third, the traffic volumes must be distributed to the various transportation modes. To make matters even more difficult, these activities are interrelated because regional growth and traffic flows will, in part, depend on transportation costs.

Regional economic forecasting models are large and expensive to develop. Adding the sophistication required to obtain detailed traffic forecasts from such models is a task suited only to the central government. The project economist should inquire about the existence of traffic forecasts for use in particular projects.

If these tasks seem unmanageable at first glance, there are a number of considerations that make the tasks more manageable. These are:

1. Most port and rail traffic is accounted for by only a few bulk items, which limits the analysis to only a few commodities.

2. Transport projects are relatively "lumpy." This means that forecasting accuracy is not as imperative. For example, if a proposed road capacity is designed for 5,000 vehicles per day, then a forecast range of 3,000 to 5,000 vehicles per day is adequate. If a port facility is justified at 80,000 tons per year and can efficiently handle up to 150,000 tons per year, then whether traffic will be 80,000 or 125,000 will not matter. On the other hand, if the forecast range encompasses the capacities of a two-lane versus a four-lane road, the choice between them will be difficult. For this reason, it is important to consider phasing the project into stages -- build the two-lane road first, and the additional two lanes later if traffic justifies it.

3. Much of the future traffic already exists for the short and medium term. Therefore, it may be more important to consider the impact from existing diverted traffic than new or generated traffic forecasted from regional growth models.

4. Because future net benefits are discounted when a net present value or economic internal rate of return is calculated, forecasts of traffic on which the net benefits are based become less important in years most distant in the planning horizon. This means that forecast accuracy in the long term need not be as accurate as the near term years.

Traffic forecasts must also be disaggregated into normal and diverted traffic. The literature also recommends that generated or induced traffic be forecasted, but for reasons already given this manual will not include this type of traffic in the analysis. As we mentioned above, in all the literature reviewed for this section, generated traffic turns out to be a very small fraction of overall traffic and, therefore, ignoring estimation of this component should not compromise the analysis.

4.2.3 Assessing Economic Costs

Transportation systems tend towards oligopolistic or even monopolistic structures because of public ownership or because the very nature of the service does not lend itself to a competitive market structure. Historically, railway services have not been priced in relation to costs but rather by the value of the commodity being transported. A related problem is found in the fact that governments often directly or indirectly subsidize transportation services. Again, this means that charges for user services of transport systems will not be related to the actual costs of providing these services. This requires that shadow prices be used to correct for these distortions so that real economic costs and benefits are used in the project economic analysis.

The use of historical costs of transport services is usually rare because of the lack of such data. Without detailed cost information, it is difficult if not impossible to know, for example, if a railway network is profitable or if the commodities could be carried at lower cost by some alternative means.

In developing cost data in economic terms for construction of a transportation facility, the use of shadow prices for labor and foreign exchange are especially important because of the high level of imported inputs and the use of large numbers of unskilled labor in land preparation work. In developing countries, a greater need exists to utilize unskilled labor in road and railway projects because doing so provides much-needed employment for rural labor and minimizes the import content of the inputs required, thus minimizing the drain on foreign exchange. This makes estimation of the shadow wage rate an important consideration.

Despite the labor intensiveness of these projects, the need to import equipment and materials is still substantial. Not only does this occur in the construction phase, but it also impacts the project throughout the planning horizon because of the need for maintenance and replacement of equipment, much of which is also imported. There also seems to be some resistance to labor-based techniques in rural road construction projects from the host country engineering departments (A.I.D., 1982, pp. 9-10) -- not surprisingly, these road engineers are oriented towards "modern" mechanized techniques. This makes the estimation of the shadow exchange rate an important consideration.

Road projects and other transportation projects require scheduled maintenance, otherwise deterioration and loss of projected benefits will invariably result. As A.I.D. (1982) points out in its project evaluation report on rural road development, the lack of a maintenance component in a rural road project led to degradation of the roads over time and projected benefits were not fully realized. A.I.D. also recommends decentralization of maintenance so that local people can participate in all aspects of maintenance work. A possible way of funding such maintenance is through user fees, which must be attributed to the project as a cost for the benefit that a maintenance program provides. As a rule of thumb, maintenance costs can be estimated at approximately 50% of the initial construction costs, to be spent in the seventh and 14th years of a 20-year planning horizon.

A related set of costs from transportation projects are those arising from the environmental effects of construction. Although frequently overlooked in practice, these costs (and more rarely benefits) can be large. Road and railway construction involve movement and shaping of large amounts of earth, rock and other materials. The actual construction practices and alignment can have significant impacts on soil erosion and habitat disruption. The location and design of borrow pits, for example, can have health effects through the creation of water pools that serve as breeding grounds for various disease vectors (such as mosquitoes). Another common effect of transportation projects is induced settlement along the right-of-way, whether or not such lands are designated for development and settlement.

While it is not possible to list all of the potential environmental and natural resource related impacts of transportation projects, an environmental analysis, as outlined in Chapter 2, can identify the major potential impacts and enter them in both a quantitative and qualitative manner in the economic analysis. In this way various design options can be evaluated to lessen the total economic costs and maximize the net economic benefits of the project.

4.3 Health Care Sector

Although the identification, measurement, and valuation of health care project benefits present unique problems for the economist, step-by-step procedures using the worksheets illustrated in Chapter 3 provide a useful framework to conduct the analysis. The purpose of this section is to highlight those analytical techniques which have been developed to handle the specific benefit or cost considerations which are unique to health care projects.

4.3.1 Assessment of Benefits

Cost-benefit analysis in the health care sector is concerned with evaluating benefits as costs to be averted if the proposed project proves effective. It is essential that the economist distinguish those present and potentially avertable costs from the resource costs required for the proposed program.

Warner and Luce (1982, pp. 82-85) offer a way to categorize benefits which can assist the economist in the identification process.

- Personal health benefits -- includes increased life expectancy, decreased morbidity, and reduced disability. Reduced pain and suffering are recognized as benefits but not usually included due to the difficulty of measuring them.

- Health care resource benefits -- includes the potential saving from a decrease in the use of medical resources both in the present and future by early treatment or prevention resulting from the proposed program. However, a screening program which identifies a disease can also result in increased use of medical resources to care for the individual, which would be considered as a cost.

- Other economic benefits -- includes those outcomes not classified above, the primary one being an increase in work productivity. Decreases in morbidity and disability can translate into improvements in work output.

- Other social benefits -- a health care program can provide more equitable access to society's health care resources.

Another classification scheme useful in the identification of benefits when applying cost-benefit analysis to health services was developed by Mushkin (1959), and according to Klarman (1974, pp. 331-335) has become the convention.

- Direct benefits -- includes averted medical resource use costs, i.e., the portion of averted costs currently borne which are associated with spending for health services and, therefore, represent potential savings in the use of health resources.

- Indirect benefits -- includes averted loss of production costs, i.e., the earnings lost due to premature death or disability which will be averted by the proposed program.

- Intangible benefits -- includes the costs of pain, discomfort, and grief of patients, their friends and relatives which will be averted by the proposed program; also, the averted premature loss of human life.

It is especially critical in the health care sector that the economist, when conducting a cost-benefit analysis, provide a listing of physical inputs and outputs (as in Worksheet 1 in Chapter 3) and a listing of linkages of benefits and costs to those physical inputs and outputs (see Section 2.4.2). As Klarman's (1974, p. 328) paper on the application of cost-benefit analysis in the health field illustrated, the presumed link between inputs and outputs (in the form of health outcomes) is sometimes tenuous. Establishment of this linkage, i.e., the impact transmission mechanism, is the key to a sound study. However, medicine is not an exact science, and physicians may disagree among themselves about the program's impact. Also, data concerning a proposed program's effects on the health of the target population is often not available.

The linkage between the physical input, physical output, and the ultimate impact is often not straightforward in health care programs because the physical output is often an intermediate step to the project's final impact. For example, if the program involved a diagnostic procedure, the intermediate physical output would be the diagnosis and the economist would have to link the diagnosis to treatment and link the treatment to the final impact on the health of the patient.

At this point the economist can specify the impact transmission mechanism, i.e., provide a description of the linkage between physical inputs/outputs and impacts (see Section 2.4.2). If that is not possible, the economist can conduct a cost-effectiveness analysis. In the example for the project which involved a diagnostic procedure, the economist may be unable to determine the final impact on the patient's health, and the cost-effectiveness analysis would rely on the number of accurate tests as the measurement to assess effectiveness.

Cost-effectiveness analysis is used instead of cost-benefit analysis to measure a project's effectiveness when either it is (1) impossible to establish a linkage between the project's physical output, as in the case of diagnosis, and the value of the final

impact, or (2) undesirable to value the physical output in terms of dollars. In these instances where cost-effectiveness is used, the health care project outputs are not valued in monetary terms but in some other unit such as years of life saved and days of morbidity or disability avoided. Its use is limited to situations where the benefits of alternative programs may be measured in the same units.

Cost-effectiveness analysis is used extensively in analyzing health care project alternatives designed to serve the same basic purpose because it presents comparison of cost per unit of effectiveness such as dollars per year of life saved. However, unlike cost-benefit analysis, it cannot be used to compare health care programs having different objectives. As Warner and Luce (1982, p. 91) have pointed out, cost-effectiveness measures involve subtle value judgments of which the economist needs to be aware. For example, "lives saved" fails to distinguish between young or old people while "years of life saved" does, but neither one considers the quality of life.

To address the need for a comprehensive measure of health care benefits which would represent quality-adjusted years of life, attempts have been made to develop health status indexes as discussed in Mushkin and Dunlap (1979). In general, a health status index assigns relative weights to death and types of disabilities in an attempt to combine a program's multiple outcomes into a single index. A health status index accepted and used by economists in conducting cost-effectiveness analysis has not been developed yet.

In situations where the benefits cannot be measured in the same units, the economist needs to value a health project's effectiveness in monetary units. Because many projects are designed to reduce injuries and death, techniques for placing a monetary value on life are critical and represent a controversial issue in the literature (Acton, 1976; Hellinger, 1980; Rice and Hodgson, 1982; Robinson, 1986).

There are numerous methods which have been used to assign a value to life of which the "livelihood-savings" or "human capital approach" and the "willingness to pay" approach predominate. Hodgson (1983) provides a review of the state-of-the-art of cost-of-illness estimates methodologies.

4.3.1.1 Human Capital Method. The livelihood-savings approach, which is referred to in recent literature as the human capital approach, is the oldest and most common means of assessing the value of reduced mortality. This measure is based on the net present value of changes in a representative person's earnings stream resulting from reduced mortality attributable to the health care project. Therefore, if the present value of the expected livelihood-savings associated with a project exceeds the present value of its costs, the project should be accepted. Even if the human capital method provides reliable estimates of forgone earnings, it omits the value of nonmarket items such as leisure, and pain and suffering.

The procedure employed in the human capital approach is straight-forward, calculating the work loss that would occur without the health project either from premature mortality or avoidable morbidity and disability. Where data exist, this work loss is categorized for each age group separately for sex, race, education level, occupation, and other pertinent variables. Appropriate wage rates are applied to each category and added up to obtain a monetary surrogate for losses in productivity.

Example 1: Estimating the Value of Lifetime Earnings. To illustrate the human capital method, the value of lifetime earnings of a man now aged 40 could be calculated in the following manner. The country's labor force definition is 10 years old and over, but for a conservative estimate of benefits the economist defines the labor force as spanning and including the ages 10 to 59. Data on lifetime age-earnings profiles, labor force participation rates, and life table values for the chances of survival are required. It is assumed that the health project will benefit the rural population. Lacking definitive studies of average income by age groups in the rural areas, the minimum wage of 3.5 pesos per day for 300 days a year will be considered the average wage of all rural workers with no opportunity to increase average annual earning as the worker gets older. A discount rate of 8% is used and the discount factors are selected for the midpoint of each age range, i.e., 2, 7, 12, and 17 years. The present value of lifetime earnings can be calculated by multiplying columns (1) through (6) in Table 4.3-1 for each age group and adding the figures as shown in the table.

This lifetime earnings calculation is then replicated for each age group impacted by the health care project and, where data are available, by sex, race, etc. Assume that the project is designed to eradicate a disease afflicting only males in the 40-54 age groups. Lifetime earnings would be calculated for the 40-44, 45-49, and 50-54 age brackets. The benefit of averted deaths for the first year from the eradication project can be calculated by multiplying columns (1) and (2) for each age group and adding the figures as shown in Table 4.3-2.

Health care projects often calculate a benefit representing the reduced earnings from disability to be averted. Using the eradication program example, the economist determines the work loss per case. Medical experts estimate the distribution of cases by age group: 60% for the 40-44, 30% for the 45-49, and 10% for the 50-54, with an average annual absence from work of six days. The average work loss per case can be calculated by multiplying columns (1) through (5) for each age group and adding the figure as shown in Table 4.3-3.

Table 4.3-1

Present Value of Lifetime Earnings for 40-44 Age Group

Age Group	Years (1)	Average Annual Earnings (2)	Labor Force Participation Rate (3)	Employment Rate (4)	Survival Probability (5)	Discount Factor (6)
40-44	5	1050	.75	.85	.99	.857
45-49	5	1050	.75	.80	.98	.583
50-54	5	1050	.75	.75	.96	.397
55-59	5	1050	.70	.70	.92	.270

Present value of
lifetime earnings = 2,840 + 1,780 + 1,125 + 639 = 6,384 pesos

Table 4.3-2

Benefits Due to Averted Deaths for Males in 40-54 Age Group

Age Age Group	Number of Deaths Averted (1)	Lifetime Earning per Death Averted (2)
40-44	480	6,384
45-49	240	5,239
50-54	80	3,810

Benefits due
to averted death = 3,064,320 + 1,257,360 + 304,800 = 4,626,480 pesos

Table 4.3-3

Average Work Loss Per Case for Males in 40-54 Age Groups

Age Group	Distribution of Cases by Age (1)	Labor Force Participation Rate (2)	Employment Rate (3)	Average Annual Earnings (4)	Average Annual Absence (5)
40-44	.60	.75	.85	1050	6/300
45-49	.30	.75	.80	1050	6/300
50-54	.10	.75	.75	1050	6/300

Average work loss per case = 8.0 + 3.8 + 1.2 = 13 pesos

Data for a health project, whether the project is disease-oriented (e.g., malaria eradication or control) or service-oriented (e.g., family planning) are needed to measure the prevalence and incidence of the disease or problem. The indicators used in the eradication illustration are examples which measure the scope of a health problem, i.e., the population at risk by region, sex, occupation and the number of deaths (mortality). Death registration in many countries provides statistics on mortality, but information on the number of cases (morbidity) and on temporary or partial work-time loss (disability and debility) is frequently nonexistent. Data sources useful for developing estimates include health interview surveys, health examination surveys, findings from laboratory examinations (e.g., slide positivity rates), and hospital statistics.

Example 2: Disease Eradication Benefits. For the three-year eradication project, medical experts estimate each year's cases as a percent of the base-year cases (which was 100,000) as follows: first year at 60%, second year at 2.5%, and third year total eradication at 0%. The estimate of base year cases (morbidity) was derived from published data on deaths from the disease for the base year of 2,000. An epidemiologist, after studying the data compiled by hospitals over a period of years, developed a mortality-morbidity ratio for the disease of 1:50. Caution should be exercised in the use of mortality statistics. For instance, Newman (1965, p. 77) presented figures for malaria where the total indirect deaths due to malaria were four times the number of deaths reported. This was due to the incorrect reporting of cause of death and, more significantly, to the fact that malaria is such a debilitating disease that it lowers resistance to other diseases. The benefit of averted disability from the eradication program can be calculated by multiplying columns (1) through (3) and adding the figures shown in Table 4.3-4.

For application in the United States, Rice and Cooper (1967) developed an approach which takes into account life expectancy for different age, sex, and racial groups, varying labor force participation rates, the current changing pattern of earnings at successive ages, implied value of housewife's services, and the discount rate, to develop tables for the present value of lost earnings due to mortality.

For a health care project designed to eradicate a hypothetical disease which is contracted only by males age 30-34, the present value of lifetime earning for the average male in this category is $434,295. This value is obtained from Rice, Hodgson, and Kopstein (1985, p. 72) which gives the value of lifetime

Table 4.3-4

Benefits Due to Averted Disability for Males in 40-54 Age Groups

Project Year	Cases Averted (1)	Work Loss Per Case (2)	Discount Factor (3)
0	0		
1	40,000	13	.926
2	97,500	13	.857
3	100,000	13	10.717*

*With eradication, the savings continue to perpetuity. The value of an annuity in perpetuity is equal to one divided by the discount rate. With the discount rate at 8%, this value is 12.5. To bring the present value to period 1, subtract the sum of the first and second year discount factors to get 10.717.

Benefits due to
averted disability = 481,520 + 1,086,248 + 13,932,100
= 15,499,868 pesos

earnings by age and sex, discounted at 6% for the year 1980. Medical opinion is that the disease strikes a male in this category with a probability of .0002, and there are currently 1,000,000 males in this age group. The benefit from eradication of the disease in the male 30-to-34-year-old cohort is then:

Benefits due
to averted death = .0002 x 1,000,000 x $434,295 = $86,859,000

Substantial theoretical criticism has been directed at the human capital method as a measure assigning a monetary value to life (Mishan, 1971). Acton (1976, p. 3-17) states that there is no satisfactory normative justification that the social value of life is equal to the present value of the individual's expected earnings. The method does not represent a full measure of society's valuation of the individual's life because it omits the value of life other than economic productivity. Although the human capital measure is a partial measure, as Robinson (1986, p. 137) has pointed out, it establishes a lower bound on the true benefit from a health project such that any project which satisfies the cost-benefit

criterion using this limited measure of benefits would pass a test using a more complete measure. In addition, if the objective of health care projects was to maximize national income, then the human capital method would have a normative basis because the economic value of an individual is the contribution he or she makes to national income. Hodgson (1983, p. 151) states the justification for the human capital approach is not that it measures the value of life, but that it does provide a measure of the cost of the disease.

Other criticisms which have been raised with the human capital approach involve (1) the assumption that the earnings of an individual reflect his economic productivity and (2) the acceptance of the current distribution of income and its wage and employment patterns places a higher priority on health care projects tending to save males of working age relative to those saving women and the elderly.

A once-controversial element of the benefit calculation using the human capital method was whether the relevant economic benefit to society from a life saved should be measured by the individual's gross productivity, which was the consensus approach, or by net productivity, i.e., gross productivity minus consumption. As Warner and Luce (1982, p. 88) have noted, a literal view of the human capital method might suggest that essential or subsistence costs of living should be deducted from gross productivity.

Another consideration which arises in a developing country with substantial unemployment is whether or not the potential productivity increase resulting from the health care project will be realized. The appropriate benefit will be calculated if the economist uses the opportunity cost for labor, i.e., the shadow wage rate.

4.3.1.2 Willingness-to-Pay Method. The willingness-to-pay method has been developed as a theoretically superior alternative to the human capital method as a technique to measure the value individuals place on reducing risks of death and illness (Mishan, 1971; Landefeld and Seskin, 1982). For example, suppose each individual in a population of 100,000 is willing to pay 18 pesos for a project that is expected to reduce the overall probability of death from 0.004 to 0.003. In that this is equivalent to a reduction in the death rate from 400 per 100,000 to 300 per 100,000, the implied value per 100 "statistical" lives saved is 18,000 pesos. The willingness-to-pay approach provides the algebraic sum of the amounts that all affected individuals are willing to pay for a proposed change in the status quo, such as a project that has life-saving potential. Therefore, if the total willingness to pay associated with the project exceeds the costs, the project results in a net increase in social welfare and should be accepted.

Whereas the human capital approach captured only the value to society of an individual's life measured by future production potential, the willingness-to-pay approach includes everything that contributes to an individual's well-being such as income, nonlabor income, the value of leisure, aversion to risk, and the value of avoiding pain and suffering. All these benefits of living are converted into monetary values.

Studies based on the willingness-to-pay approach have been undertaken using both surveys and using an analyses of "revealed preferences." With direct survey responses from individuals, the data must be gathered through questions which ask people to state their willingness to pay for the project benefit, or what they would pay to reduce a given amount of risk. Depending on expensive survey techniques with questionable reliability of responses has made it impractical to apply this approach on a regular basis. A few studies have been undertaken such as Acton (1973) and Jones-Lee (1976). In the former, Acton analyzed programs that reduce chances of heart attack death. Individuals were asked 23 questions on willingness to pay and provided bar graphs illustrating the probabilities involved. Acton's (1973, p. 119) basic willingness-to-pay question was:

> Let's suppose that your doctor tells you that the odds are 99 to 1 against your having a heart attack. If you have the attack, the odds are 3 to 2 that you will live. The heart attack program would mean that the odds are 4 to 1 that you live after a heart attack. How much are you willing to pay in taxes per year to have this heart attack program which would cut your probability of dying from a heart attack in half (i.e., the chances are 2 per 1,000 you will have a heart attack and be saved by the program this next year)?
>
> $_____

Respondents indicated that they would be willing to pay $56 on the average, to reduce their chance of dying from a heart attack by 0.2% (i.e., 2/1000), from an existing 2/5 chance of death to 1/5, which implies a willingness to pay of $28,000 per statistical life saved.

Value of statistical life = $56 / 0.002 = $28,000

As one result of his study, Acton (1976, p. 31) argues that the human capital approach and the willingness-to-pay approach frequently lead to reasonably survey-based close measures of the value of life. He also observes that because the analysis is often an order-of-magnitude evaluation, the drawbacks to either approach are second-order magnitudes and do not affect the conclusion whether to undertake the program.

Because using the survey approach to determine willingness-to-pay estimates of the value of life has proven difficult, studies have been undertaken to determine estimates based on observations of compensation necessary to induce individuals to voluntarily assume risk. Landefeld and Seskin (1982, p. 557) provide a review of the literature which has proceeded along two directions: (1) labor market studies that have examined the extra compensation necessary to induce workers to take risky jobs, and (2) prices associated with consumption activities such as the purchase of seat belts or smoke detectors. These "revealed-preference" studies have resulted in a wide range of estimates for the value of life.

Each application of the willingness-to-pay approach requires a study, making the method time-consuming and expensive. The state-of-the-art has not achieved the level where a table of willingness-to-pay estimates can be developed to apply to any project and maintain acceptable reliability. Landefeld and Seskin (1982) have contributed a new measure, the adjusted willingness-to-pay/human capital estimate which combines the positive aspects of the human capital approach and willingness-to-pay approach for estimating loss of life. Only further research and applications will tell if this is a practical and reliable approach. In their article they provide the summary table shown in Table 4.3-5 which is useful in comparing the alternative methods for valuing lives.

4.3.1.3 Medical Resources Benefits. In addition to benefits from the averted loss of productivity, health care projects also offer potential savings from medical resources no longer required. In the eradication project illustration, the average medical resources cost per case is estimated at 25 pesos. Without the project, 100,000 cases will arise annually to perpetuity. This without-project cost is calculated as:

Present value of medical
resources costs
without project = 100,000 x 25 x (1/.08) = 31,250,000 pesos

With the eradication project, the annual number of cases is multiplied by the average medical resources cost per case of 25 pesos and then discounted back to the present as shown in Table 4.3-6.

Table 4.3-5

Alternative Methods for Valuing Lives

Method	Expression	Comments
1. Human Capital	$\sum_{t}^{T} \frac{L_t}{(1+i)^t}$	T = remaining lifetime L_t = labor income[1] i = OCC of investing in life-saving
2. Revealed-Preference Willingness to Pay Where:	$\left[\sum_{t}^{T} \frac{B_t}{(1+p)^t}\right]^a$	B_t = benefits of living = $L_t+NL_t+NM_t+P_t$ L_t = labor income[1] NL_t = nonlabor income NM_t = nonmarket activities & leisure P_t = premium for pain & suffering p = individual rate of time preference a = risk-aversion factor
3. Adjusted Willingness to Pay/Human Capital Where:	$\left[\sum_{t}^{T} \frac{Y_t}{(1+r)^t}\right]^a$	Y_t = after-tax income = Lt + NLt r = individual's opportunity cost of investing in risk-reducing activities

[1] May include the imputed value of nonmarket time spent on housekeeping activities.

Source: J. Steven Landefeld and Eugene P. Seskin (1982), "The Economic Value of Life: Linking Theory to Practice," American Journal of Public Health 72(6), p. 560.

Table 4.3-6

Present Value of Medical Resources Costs with Project

Program Year	Number of Cases (1)	Medical Resources Costs Per Case (2)	Discount Factor (3)
1	60,000	25	.926
2	2,500	25	.867
3	0		

Present value of medical resource costs with project = 1,389,000 + 54,188 = 1,443,188 pesos

Incremental Net Benefits due to averted medical resources costs = 31,250,000 - 1,443,188 = 29,806,812 pesos

4.3.1.4 Family Planning Benefits. The approach to cost-benefit analysis for family planning projects is similar to that discussed for the health care sector in that the analysis is concerned with benefits representing costs which would be averted if the proposed project proved effective. The benefits from averting an unwanted birth then require estimates of costs which can be avoided such as cost of pregnancy, birth, and child rearing. Specific methods have been developed for measuring the averted births attributable to family planning and for assigning an economic value to an averted birth.

The calculation of benefits for a family planning project involves two stages. The first stage is to measure the births averted by the project in terms of years, and the second stage is to determine the economic value of averted births.

Several statistical techniques have been developed to measure the impact on fertility of family planning projects (United Nations, 1979, 1982, 1985, 1987). Nortman (1985) provides a critique of the nine existing methodologies to measure family planning impact on fertility. Some applications do not lend themselves to the assessment of the potential impact on fertility from the proposed project. Most appropriate for determining future births averted is the component projection method for which a computerized version is available from the United Nations and a hand calculator version is presented in United Nations (1979, pp. 73-75).

The component projection for the hand calculator illustrates the data required to estimate averted births. An assumption made is that no family planning program participants would have been protected against pregnancy in the absence of the project. The number of births averted by couples or women in age group "i" is:

$$\text{Averted births } i = Q_{i,t} \cdot g_i$$

The first step is to estimate the $Q_{i,t}$, the number of women in the ith age group in year t who were practicing contraception. This requires estimates of the number of acceptors by family planning method (i.e., intrauterine devices, oral contraceptives, condoms, etc.), age group, and year of acceptance. Translating the number of acceptors into number of users requires continuation rates by age group, type of family planning method, and duration of use reflecting the length of the period of time births will be averted due to the project.

In the second step, the value of gi, the potential fertility estimate of the women in the ith age group, is multiplied by the number of women in the ith age group to obtain the number of averted births for the ith age group. For gi the age-specific marital fertility rates of the population as a whole could be used. The total averted births due to the family planning project will then be the summation of the averted births for each age group.

With the impact of the family planning project provided by a demographer in terms of averted births, the second stage in the analysis is to determine the economic value of an averted birth. However, instead of determining the economic value of an averted birth a cost-effectiveness analysis can be conducted. The intermediate output, averted births, is used to define a measure such as births averted per dollar of cost, and the task is one of determining the most effective family planning project for reducing fertility.

The approach to determine the value of an averted birth using an econometric simulation model of the country's economy will not be reviewed because its development involves substantial resources and time. The interested reader is referred to Coale and Hoover's (1958) classic study on India. More recently, Sommers' (1980) model was constructed based on data covering a cross-section of 67 countries. Sommers applied his model to 17 developing countries at a 10% discount rate assuming family planning averted 40,000 births annually for 15 years except for smaller countries where it was scaled down to 10,000 births annually for 15 years. The results indicated that an averted birth was worth anywhere from a low of 19.6 times annual per capita income (Indonesia) to a high of almost 41 times per capita income (Taiwan). Ratios for 12 of the 17 developing countries were between 31 and 36.

The most common approach takes the net present value of the discounted consumption stream of an unborn child as the main measure of the benefit occurring to society of an averted birth. The net benefit of an averted birth would then be the present value of the difference between lifetime production and lifetime consumption of birth at the margin.

This approach developed by Enke (1966), has been criticized by Simon (1969) and others because it can lead to the implausible result that a birth rate not far from zero is economically the most desirable in all countries at all periods of time. The discounting process is the primary cause because an individual's production which doesn't start until age 10 to 15, is more heavily discounted than consumption which begins at birth.

Other criticisms have been made of this approach where the benefits of family planning are the costs forgone from an averted birth. The extent of these costs to society is less clear because the actual cost of a child will fall on its parents and lower the average subsistence per family member. It is also argued that the parents' choice to have an additional child represents a welfare-maximizing course of action from their viewpoint in that children provide benefits such as support in old age, unpaid labor for the family farm, or simply enjoyment for the parent. As Robinson and Horlacher (1971, p. 6) have pointed out, accepting these arguments implies that net benefits would accrue to the families from birth control only if (1) they could not accurately judge their own welfare-maximizing family size or (2) were unable to limit their number of children, thus exceeding the desired family size.

Zaidan (1968) extended Enke's approach by including other societal benefits, such as the increase in labor productivity from improved diet, the increase in private savings, and the decrease in required public welfare spending. Recent cost-benefit studies for the United States (Jaffe and Cutright, 1977; Chamie and Henshaw, 1981) and for California (Wray, Roth, Fowler, and Harp, 1981) take the approach of limiting the analysis to (1) the costs borne by government for a birth and (2) the benefits as government expenditures that would have been associated with a birth had it not been averted. Comparing these impacted savings of the government expenditures with government expenditures for a family planning project will give a cost-benefit ratio for the government's funds used in the project. This approach doesn't capture all the changes to national income which can be attributable to the project.

In the cited California study, the benefits were those government expenditures on medical services (abortion, delivery, continuing service), social services (foster care, adoption, day care), development disabilities (mild, moderate, severe), and cash

grants that would have been averted by available family planning. In order to provide conservative estimates, the time span over which these averted government costs are estimated was limited to two years, except for development disabilities which covered 20 years.

Limiting the analysis to two years for most benefits attributable to the family planning project overcomes a problem in applying cost-benefit analysis to human resources projects, an aspect which Haveman (1976, p. 49) refers to as the "durability of effect problem." These projects apply a "treatment" (e.g., birth control) at one point in time which will alter behavior into the future. It is necessary to extrapolate performance into the future, usually on limited data, on the rate at which the effect of the project either decays or multiplies over time. The future effect of family planning projects is based on the continuation rates for the various birth control methods.

The reduction in the probability of pregnancy was determined based on data indicating that a woman trying to avoid pregnancy (but not using formal family planning services), on the average, has a 27% chance of pregnancy within a year whereas a woman using family planning services has a 6% chance of pregnancy within a year. Therefore, by using family planning services a woman reduces her annual probability of pregnancy from 0.27 to 0.06, or 21 percentage points.

Next, the total expected government cost per pregnancy was calculated by totaling the expected costs per pregnancy of the various publicly funded services. The expected government cost of a service per pregnancy was obtained by taking the probability that a woman would use the publicly funded service if she became pregnant and multiplying this probability by the cost of the service. For example, the average cost of delivery (prenatal care, delivery, postnatal care) was $1,438. For the 45% of pregnant women who will give birth (the remainder have abortions), the possibility of perinatal death must be considered. The perinatal death rate was 1.5/1,000 live births; therefore, the 0.15% of the 45% or 0.07% of these pregnancies will result in perinatal death. With an estimate of 60% of the women having babies using the government medical services, the expected delivery costs per birth can be calculated as shown, using a 10% discount factor for nine months.

Expected Government Delivery Cost per	=	Average Cost Per Birth	x	Probability of Giving Birth	x	Probability of Using Government Program	x	Discount Factor
	=	$1,438	x	0.449	x	0.60	x	0.928 = $359

For each of the various government services associated with pregnancy, a similar calculation to that for medical services for

delivery is made and the results summed to obtain the total expected government cost per birth. If it is assumed that the only government program was medical services for delivery, then the expected benefits would be the delivery costs which would have been avoided had family planning services been provided.

Expected Benefits per Woman-Year from Family Planning	=	Probability of Birth without Program	x	Cost for Delivery	-	Probability of Birth with Program	x	Cost for Delivery

$$= (0.27)(\$359) - (0.06)(\$359)$$
$$= \$96.93 - \$21.54 = \$75.39$$

4.3.2 Assessment of Costs

Cost estimates of medical resources used for a health care project provide the economist with information needed to place a value on the benefit of the potential saving from a decrease in use of medical resources resulting from the project and the cost of resources to implement the project. Common to determining both benefits and costs are the steps of measuring and valuing the resources saved or consumed by the project. However, before these steps are undertaken, the economist must identify the inputs used in the project.

As Warner and Luce (1982, p. 78) have stated, it is crucial that the cost analyses begin by identifying the actual inputs used and, where possible, their quantities. All the physical inputs required to produce the project's desired outputs should be enumerated using the type of spreadsheet as in Worksheet 2 in paragragh C.1.1. The costs of these physical inputs may not represent all of the project's costs to society. The impact transmission mechanism should be used to identify any other costs to society.

Typical inputs for health care projects are hospital care, outpatient clinical care, nursing home care, home health care, physicians and other medical services, drugs, medical supplies, rehabilitation counseling, administration, construction, research, training, and volunteers' time. Other less obvious costs may include cost of transportation to health providers, household expenditures incurred in caring for a sick member of the family, value of patient's time, and future medical care expenditures not related to the disease that would have to be borne if the individual did not succumb to the disease.

Another cost estimation problem in health care projects is joint costs. For example, a proposed family planning project will be part of an existing comprehensive maternal and child health project with administration, field workers, and clinics already established. How much of the costs of the maternal and child health program should be allocated to the family planning project? Any marginal inputs such as additional field workers are easy to identify. The difficulty is with the administration or overhead costs. Additional administrative costs need to be identified and included as costs to the family planning project. The general principle is to determine these marginal inputs, but often that proves difficult and the economist reverts back to allocating the joint costs proportionally to each project based on some measure such as expenditures.

4.3.3 Health Costs and Benefits as Indirect Effects

The preceding discussion focussed on the use of standard techniques for evaluating the economic benefits and costs of health projects. The same approaches can be used to place monetary values on the health-related benefits and costs that arise as indirect results of development projects. As discussed earlier, many resource using projects have off-site, unintended impacts on the environment or natural resource base. To the extent that these impacts affect human health, they should be measured and included in the economic analysis.

The economist begins by identifying the potential impacts by using a modified impact transmission mechanism approach. Sometimes the impacts are fairly direct and one can reasonably establish a cause and effect relationship. Changes in water quality and the resulting incidence of certain water-borne diseases is one example. The creation (or removal) of vector breeding grounds and resulting disease transmission is another example. In other cases the cause and effect relationship is more difficult to establish. Air pollution is a notoriously difficult case; the diffuse nature of the interaction between multiple pollution sources and multiple receptors (usually humans) makes establishing a cause and effect relationship a major, sophisticated statistical exercise.

It is clear that the economist must work with health experts in establishing these interactions. Once estimates are made of physical links, the analytical tools outlined here can be used to assign monetary values to either negative health effects (costs) or health costs avoided as a result of the project (benefits). If done early in the project design stage, such information can be useful in evaluating alternatives in order to minimize costs and maximize benefits.

4.4 The Financial Sector: Economic Appraisal of Lines of Credit and Equity Investments

Many development finance companies (DFCs) in the developing nations receive external financing in the form of both lines of credit and equity investment. This finance may be supplied by domestic financial institutions, such as the central bank or commercial banks, or by the sale of equities to domestic investors, which may be by placement or by issues on the stock market. However, a significant amount of external finance is provided by foreign sources, notably multilateral development institutions (MDIs) such as the World Bank, the Inter-American Development Bank, the African Development Bank, the Asian Development Bank and some bilateral aid agencies, notably the USAID. All these external finance institutions need a methodology for appraising their investment in the DFC. Private-sector sources are concerned only with a financial appraisal, but public-sector organizations, especially MDIs and bilateral aid agencies, are concerned also with the national economic impact of finance supplied to the DFC. This implies that these organizations should apply some form of social cost-benefit analysis in appraising lines of credit or equity investments.

A recent internal guideline of the Asian Development Bank expressed its position as follows. "However, it is now expected that in subloan appraisals, a DFC should go a step further (than commercial profitability) and make sure that the subprojects to be financed are also beneficial to the society as a whole. It is well known that private profits are not always synonymous with social gain." (Asian Development Bank, 1984, p. 2)

The techniques for the financial and socio-economic appraisal of individual investments are well known. The DFCs can reasonably be expected to apply these techniques to the investments, or to subprojects they consider. Because an external organization providing a line of credit or equity does not know in advance which particular subprojects will be financed from its funds, it cannot use conventional project appraisal techniques to appraise its investment in a DFC. What procedures, then, should it adopt to try to ascertain that the financial and national economic benefits arising from the DFC's subprojects will justify the initial provision of funds? This section proposes some approaches which help to answer that question.

The assessment of national economic benefits is relevant in economies where significant distortions exist between private and social profitability. Sometimes this divergence is due to the existence of sizeable environmental and natural resource effects that are not included in the private financial analysis but should

be part of the aggregate economic analysis. Where such distortions are not significant, the national economic benefits will approximate private profitability. Therefore, Section 4.4.2 concerned with financial appraisal will apply equally to the assessment of DFCs and venture capital funds in the industrialized countries as well as in the developing countries.

4.4.1 Procedures for Lines of Credit

It is convenient here to briefly discuss procedural arrangements for foreign lines of credit. Those provided by official bilateral or multilateral agencies are supplied initially to a developing country government for on-lending to a DFC. It is common practice for the government to add a considerable interest rate mark-up. This means that the government itself usually absorbs the benefit of any concession in the line of credit, and the DFC receives the funds on quasi-commercial terms, although in some cases a degree of concession may be left in by the recipient government. Therefore, if a government receives a $1 million line of credit at 8%, and on-lends it to the DFC at 12%, the government receives a grant of 4%, or $40,000 per year, during the maturity of the loan. From the government's point of view, the interest rate mark-up may be merely compensation for the risk it accepts in guaranteeing the loan. But from the point of view of the lender, part of the benefit of the line of credit accrues to the government and part to the DFC.

A related question arises in connection with the assumption of the exchange rate risk. In some cases, it may be absorbed by the recipient government, and again the interest rate mark-up provides some compensation for the assumption of this risk. In others, the government may pass on the exchange rate risk to the DFC, which sometimes may pass it on to the ultimate borrowers. In some countries, there may be possibilities for hedging the exchange rate risk on forward currency markets. Of course, if the risk is not hedged, then a sharp adverse movement in exchange rates could mean that the exchange rate loss to the borrowing country outweighs any economic benefits arising from the lending program. This is an important consideration, and may create financial problems for the government, the DFC, or its clients. Here, we will allow for the risk by applying a shadow exchange rate (SER) to the initial value of the line of credit.

4.4.2 Financial Appraisal

The financial analysis of the DFC and its loan portfolio will provide the basis for the subsequent economic analysis. A number of different approaches to the financial analysis are possible and we will discuss them in turn.

4.4.2.1 Historical Analysis of the DFC. An examination of the DFC's accounts over the last five years will reveal its overall profitability. This in turn reflects the success of the DFC in

recovering its interest and loans, and the extent of provisions against bad loans. These indicators will give an impression of the overall success of the DFC in identifying good potential customers. However, only general conclusions can be drawn from these indicators. For example, if there is a high margin between the DFC's lending rate and cost of funds, it may be difficult not to make profits. On the other hand, the ability of the DFC's clients to service their debts indicates only a base level of profitability; the true profitability of client companies may be very much higher. Likewise, if a DFC provides a significant proportion of its funds in the form of equity, then the valuation of the equity, assuming it is unquoted, would be difficult, and could well be understated in the accounts. Analysis of DFC accounts can provide only a starting point.

The provision of equity capital by a DFC is likely to be most marked in Islamic countries and institutions, where debt is frowned upon.

4.4.2.2 Analysis of the DFC's Loan Portfolio. An examination of the loan portfolio can provide a figure for nonperforming loans (i.e., loans with interest or repayment of principal in arrears). As a rough guide, nonperforming loans might be expected to be about 10% of the total. If the figure falls much below that, the bank has probably not been prepared to undertake the sort of risky investment expected of a DFC; much above that, and the DFC has probably been lending unwisely.

A more useful indicator obtainable from examining clients' accounts is the pre-tax rate of return on capital employed. This figure is a good indicator of the financial return to the economy arising from investment projects the DFC has financed. The figure should be calculated as an average over a five-year period in order to smooth out cyclical fluctuations. It may then be compared with the rate of return on capital employed for the whole economy, calculated from national statistics, to see whether DFC clients outperform the entire economy. This approach switches the emphasis from the profitability of the DFC to the profitability of client companies, giving a better impression of the total financial returns resulting from the DFC's operations.

4.4.2.3 A Portfolio Approach to DFC Lending. Modern capital market theory suggests that in a perfect capital market, a perfectly diversified portfolio will, in the long run, give the same rate of return (or rate of growth) as the whole market, or national economy. The only way the investor can beat the market is by luck, good forecasting, or insider dealing. If we view the DFC's client companies as an investment portfolio, we can compare their aggregate rate of return with the rate of growth of the entire economy over, say, five years. Given the DFC's access to inside information before deciding whether to finance a client company, and given its

presumed professional forecasting skills, one can assume that DFC clients should, in aggregate, give better performance in terms of return on capital employed and growth than does the entire economy.

If the DFC clients do not, in aggregate, perform relatively well, a number of explanations are available. First, the DFC may not hold a well-diversified "portfolio" of clients. It may be a specialized institution, concentrating on agriculture (such as an agricultural credit bank), on small business lending, or on residential property (such as a savings and loan bank). In such cases, the performance of the DFC's clients will reflect the performance of the sector, which may be inferior to that of the national economy. A second and similar explanation may be that a fairly diversified DFC is excluded from some key economic sectors, such as mineral exploration and development, claimed exclusively by government enterprises or foreign investors. A third explanation, of course, is that although diversified, the DFC has performed badly at selecting investment clients and has not forecast technical and economic trends well. All these possibilities must be considered when appraising a new line of credit to a DFC.

4.4.2.4 The DFC's Portfolio Balance. Some DFCs have a well-diversified portfolio of client companies; others have portfolios weighted towards certain sectors, and may even be specialized in one sector, such as industry or agriculture. Because the returns to investment in different sectors may differ, it is important to know how the DFC expects to apportion its new line of credit between or among sectors. This may be left to the DFC's discretion or may be predetermined by the foreign lender.

A further consideration in the breakdown of the portfolio by sector is that different sectors may have different specific risks. Some sectors may be relatively volatile, growing faster than gross domestic product when the latter is growing, but falling faster when it is falling. Such a sector would be a relatively high risk. In many developing countries, the industrial sector probably would constitute a relatively high risk. Conversely, other sectors may be relatively stable, responding less to changes in macroeconomic growth. Traditional or subsistence agriculture would probably fall into that category. The relevance of the riskiness of different sectors is that it may be important to take into account when estimating the expected benefits from investment in each sector.

For most practical purposes, it will probably be sufficient to apportion the investment of a new line of credit among industry, agriculture, and other (e.g., services and tourism). However, in some instances the line of credit may be tied to a specific sector, such as small industry, export industry, food processing, or tourism. In such cases, more detailed information on sector returns and risks may be needed.

4.4.2.5 Estimating Costs and Benefits. The objective of the current exercise is to show how the expected financial rate of return on a new line of credit supplied to an existing DFC may be estimated. This will not be the rate of return to the DFC, but rather the rate of return on all the investment generated. We will then use this approach as the basis for estimating future economic rates of return.

Investment Costs: The line of credit is a supply of investment funds which may be provided as debt or equity. Here, it does not really matter which for we are estimating the return to total capital employed. The capital supplied by the DFC will be supplemented by funds from the client company and other lenders and investors, a ratio which will be fairly predictable from the DFC's practices. Therefore, 100 pesos of investment from the line of credit will draw out further investment, say p pesos, i.e., for every 100 pesos supplied as the line of credit, total investment will be (100 + p) pesos.

Of course, not all the line of credit will be invested in year 1. It may be expected to be disbursed over, say, three years, in which case it would be appropriate to allocate one-third of the line of credit (plus parallel investment) to each of the years 1 to 3. Working capital should be similarly staggered. The profits arising from the investment should also be staggered accordingly, so that profits from investments in year 1 would arise over years 2 to 11, from investments in year 2 over years 3 to 12, and from investments in years 3 over years 4 to 13. We will make the not unrealistic assumption that profits in the year following the investments are zero.

Working Capital: Assuming that the line of credit will be used to finance fixed assets and associated expenditure, such as engineering costs and pre-operating expenses, working capital will be financed from other sources, typically short-term commercial bank credits. Because the subprojects to be financed from the lines of credit are unknown when the credit is granted, it is not possible to precisely estimate the associated working capital requirements. The procedure then would be to estimate working capital requirements as a proportion of fixed assets (i.e., as a proportion of the investment costs, (100 + p) pesos. This can only be done on the basis of the DFC's previous experience, and an estimate of working capital requirements as a fraction of fixed assets must be estimated from a sample of the DFC's previous investments. If desirable, it will be possible to derive separate figures for different sectors, such as industry, agriculture, food processing (where working capital requirements can be very high when food production is seasonal), and any other sectors.

Net Benefits: The rate of return on capital employed, before tax and interest, can be calculated from the accounts of existing DFC clients. Where necessary, the portfolio can be divided into sectors, and returns for each sector calculated. These rates of return can then be applied to the total investment cost (fixed assets plus working capital) to obtain a figure for net benefits. This is obviously a crude approach, but probably the only one available for estimating the aggregate benefits of a portfolio of unidentified subprojects.

If the line of credit is to be allocated to different sectors, and if the expected returns from each sector are different, then allowances can be made at this stage. Note that the expected rates of return should embody each sector's different risks discussed above.

The return to the portfolio may be calculated from the following sector breakdown.

Sector	Expected Fraction of Portfolio	Expected Rate of Return on Capital Employed, Before Tax and Interest (%)
Industry	a	x
Agriculture	b	y
Other	c	z

The average annual percentage return on the portfolio is then:

$$ax + by + cz$$

This return is net of all operating costs and is calculated before tax and interest. Depreciation has been subtracted in calculating the annual profits, but has also been subtracted from the investment cost in obtaining a figure for capital employed.

An investment cost of (100 + p) pesos in year 1 can then be said to give returns of:

$$(ax + by + cz) \times (100 + p) \text{ pesos}$$

over years 3 to 11 (the return in year 2 being zero), and an internal rate of return can be calculated. The above return is an expected average over the lifetime of the project. As returns will probably be lower in earlier years than later years, it is prudent to assume that the return in year 2 is zero. We also assume that there will be no replacement investment in the intermediate years, and that there is no residual value.

Of course, not all the line of credit will be invested in year 1. It may be expected to be disbursed over, say, three years, in which case it would be appropriate to allocate one-third of the line of credit to each of years 1 to 3. The benefits should be staggered in the same way.

4.4.3 Economic Appraisal

Assuming that the individual subprojects to be financed are not known, the most that can be done by way of economic appraisal is to attempt a crude breakdown of investment costs, working capital, and net profits into the components of foreign currency, local currency, and labor. We will then apply the traditional method of shadow pricing, using a shadow exchange rate, a shadow wage rate, and an opportunity cost of capital.

4.4.3.1 Investment Costs. Because the line-of-credit part of the investment cost is a foreign currency cost to the economy, it should receive shadow pricing. This process will capture the exchange rate risk mentioned above. From the point of view of the national economy, it does not matter whether the exchange rate risk is borne by the government, the DFC, or the borrowing client; it is always there. In most subprojects, the line of credit will be used to finance the foreign exchange costs of the project; therefore, the parallel investment, p, may be regarded as a local currency cost. There will be some labor costs also in p, but these are likely to vary considerably from one subproject to another. Ideally, a sample of past DFC projects would be analyzed to estimate the expected labor component of the investment costs, but in many cases the cost estimates of past projects will not separate out labor. Probably the best possible effort is to intelligently guess at the proportion of total investment costs which consists of payment to unskilled labor.

The investment costs on which the above rate of return was calculated may well contain an element of import duty should the country typically charge import duty on capital goods. If that is the case, the new investments generated by the line of credit can also be expected to include an element of import duty. The best way to handle this is to reduce the estimated investment by the average rate of import duty on capital goods.

4.4.3.2 Working Capital. A proportion of the working capital requirements of DFC subprojects will be in foreign exchange, for example, to pay for imported materials. Again, an analysis of past projects may be the best guide to the proper proportion. But if that's impossible, the economist must rely on an intelligent guess.

4.4.3.3 Operating Costs, Labor Costs, and Sales Revenue. In the previous section on costs and benefits, operating costs, labor costs, and sales revenues were aggregated in net profit before

interest and tax. Because most DFC subprojects produce an output which is traded (either an export or an import substitute), it is reasonable to consider that the sales revenue is a foreign exchange item. Likewise, many of the operating costs, such as materials, will also be traded, although significant nontraded items may arise here, such as power, transport and other services. The main exception is likely to be labor. The best approach may be to take a figure for the capital/labor ratio (or investment cost per job) of the economy (or, even better, a sample of previous DFC subprojects) and estimate the labor costs accordingly. Thus, if the investment cost per job is found to be 10,000 pesos, then an investment of 1 million pesos would create 1,000 jobs. If the wage rate is 2,000 pesos per year, then the wage bill would be 5 million pesos per year. The labor cost is then subtracted from the net profit before interest and tax to give a new benefit figure, equal to net profit before labor, interest, and tax. If data permit, this can be divided into local and foreign currency, but a reasonable simplification may involve treating it all as a foreign currency item.

Of course, this simplification takes no account of the nontraded inputs and outputs which are included in net profit before interest, tax, and labor. Some inputs, notably transport, power, and water, may be substantial. On the other hand, some projects will have nontradeable outputs, for example, buildings, bridges, some services, and low value goods such as bricks. We feel that for a portfolio of projects, the nontraded inputs and outputs will largely cancel each other out, and that any residual balance of nontraded items is likely to be small.

Probably the best one can do regarding net profit before interest, tax, and labor is to regard the item as traded and therefore a foreign exchange item. For purposes of economic appraisal, however, labor then becomes a cost item and is shadow priced appropriately.

4.4.3.4 Sectoral Estimates. To this point, we have assumed that the different investment sectors of the DFC's expected portfolio are aggregated. If desirable, it would be possible to estimate for individual sectors the likely labor component of investment costs and the different capital/labor ratios. It may also be that operating inputs are substantially nontraded in one sector, in which case it may be desirable to try to separate them from the traded inputs.

4.4.3.5 Summary of the Economic Appraisal. Performing the above analysis permits one to make a rough calculation of the direct economic costs and benefits of the investment of the line of credit.

4.4.4 Concluding Remarks

The procedure is necessarily crude but, in general, it is likely to give a reasonable guide to the economic benefits attainable from extending a line of foreign credit to a DFC. The method captures the growth to be expected from new subprojects over time, as it uses estimates of rates of return on capital employed from a variety of existing subprojects. The method proposed does not capture the external benefits which may arise, possibly appearing in the form of increased profits to existing firms and increased employment. However, there may also be external costs, such as environmental damage and declines in profits and employment in existing firms if competition increases due to new subprojects. Overall, one hopes that external benefits would outweigh external costs, but it appears impossible to estimate even crudely what they might be, so it is better to ignore them in appraising lines of credit to DFCs.

Although crude, the methodology is probably not inferior to methods of estimating benefits of nonrevenue-earning infrastructure of social services projects, where the benefits must be imputed.

C.2 Case Study: Appraisal of a Loan to a DFC

This case study illustrates the application of the methodology described previously to a line of credit made by A.I.D. to a development finance company. We will call the country Poyais and the company BANDESSA. It is a tropical country with a reasonably well-developed agricultural sector, but relatively little agricultural processing or manufacturing industries. The objective of the loan is to encourage the development of the manufacturing and agricultural processing sectors, but the latter requires some funding to modernize existing agriculture so that it can reliably supply processors with the right type and quality of products at the right time. Discussions between A.I.D. and BANDESSA have tentatively concluded that about 20% of the line of credit will be used for agriculture, 50% for agricultural processing, and 30% for manufacturing. The line of credit will be U.S. $9 million converted to 9 million pesos at the official exchange rate of 1:1 which, it is hoped, will be disbursed over three years. A.I.D. undertook an economic appraisal of the line of credit, and BANDESSA agreed to use economic cost-benefit analysis on all subprojects to ensure that each has an adequate economic rate of return.

Before the economic appraisal of the line of credit is shown, a financial assessment is completed as follows.

C.2.1 Financial Assessment

C.2.1.1 Investment Costs. In addition to the funds provided by the line of credit for financing the foreign expenditure components of subprojects, BANDESSA has agreed to match it with $9 million equivalent in local currency or 9 million pesos. BANDESSA is willing to provide both equity and loan capital to subprojects, but has a rule that it will not provide more than 60% of the long-term capital required by any project. An analysis of its project financing over the past three years indicated that BANDESSA had provided 38% of the long-term capital of the projects it had financed. Therefore, if a similar proportion is maintained (rounding to 40%), the amount of new investment (million pesos) associated with the line of credit is as shown in Table C.2-1.

The investment has been spread equally over three years, the disbursement pattern intended by BANDESSA.

Table C.2-1

Amount of New Investment
(million pesos)

	Year 1	Year 2	Year 3	Total
Foreign currency - line of credit	3	3	3	9
Local currency - BANDESSA	3	3	3	9
Local currency - investors	9	9	9	27
Total	15	15	15	45

Table C.2-2

Working Capital Requirements
(million pesos)

Sector	% of Portfolio	Capital Investment	Working Capital as % of Capital Investment	Working Capital	Of Which Foreign	Of Which Local
Agriculture	20%	9	25	2.25	0.56	1.69
Agricultural Processing	50%	22.5	40	9.00	2.25	6.75
Manufacturing	30%	13.5	25	3.37	0.84	2.53
Total		45.0		14.62	3.65	10.97

C.2.1.2 Working Capital. BANDESSA does not provide working capital. Subprojects are expected to get it from the commercial banks. Obviously, working capital requirements vary from project to project, but experience indicated that agricultural processing projects, partly because of their seasonal nature, tended to need more working capital than others. An examination of BANDESSA's subprojects over the last three years suggested that in aggregate, initial working capital requirements came to about 25% of capital investment. For agricultural processing (which BANDESSA has little experience in financing), it was decided to take a higher figure of 40%. A "best guess" figured that about 25% of working capital requirements would be in foreign currency. The working capital estimates are contained in Table C.2-2.

In completing Worksheet 2 (a variation on Worksheet 2, Chapter 3), the working capital requirements are divided evenly between years 1, 2, and 3.

Worksheet 2

Financial Cost-Flow Statement
(million pesos)

	Years		
	1	2	3
Investment Costs	15.0	15.0	15.0
Working Capital	4.87	4.87	4.87
Total	19.87	19.87	19.87
Local Currency	15.65	15.65	15.65
Foreign Currency	4.22	4.22	4.22

C.2.1.3 Cash Flow. An analysis of BANDESSA's subprojects over the last three years gave a weighted average rate of return on capital employed, before tax and interest, of 16%. The rate was calculated by aggregating all the profits before tax and interest, and aggregating all the capital employed (as measured by fixed assets plus current assets minus current liabilities). A separate analysis of agricultural, agricultural processing, and manufacturing subprojects gave rates of return on subprojects in these sectors of 12%, 17%, and 20%, respectively. Given the differences between these rates of return, it was considered advisable to divide the portfolio into three components and to calculate as a weighted average rate of return on future investments, as shown in Table C.2-3.

Table C.2-3
Average Rate of Return on Future Investments

Sector	Expected Fraction of Portfolio	Expected Rate of Return on Capital Employed, before Tax and Interest
Agriculture	0.2	12%
Agricultural Processing	0.5	17%
Manufacturing	0.3	20%

Annual rate of return on portfolio = 0.2 x 12 + 0.5 x 17 + 0.3 x 20
= 16.9%, or, say 17%.

Table C.2-4
Financial Cash Flow Arising from DFC Subprojects
(million pesos)

	Years						
	1	2	3	4	5-11	12	13
Investment Costs	-15.0	-15.0	-15.0				
Working Capital	-4.87	-4.87	-4.87				
Total	-19.87	-19.87	-19.87				
Net Profit before Interest and Tax (17%) (a)	-	0	3.38	3.38	3.38	-	-
(b)	-	-	0	3.38	3.38	3.38	-
(c)	-	-	-	0	3.38	3.38	3.38
Cash Flow	-19.87	-19.87	-16.49	6.76	10.14	6.76	3.38

IRR = 7%

Table C.2-4 can now be completed from the information contained in Table C.2-2 and Table C.2-3. The only tricky point concerns the timing of the returns. We assume that the return in the year following the investment is zero and that equal returns are earned each of the following nine years. In the completed Table C.2-4 below, returns have been calculated for each year's investment separately with (a) referring to returns on year 1 investment, (b) to returns on year 2 investment, and (c) to returns on year 3 investment.

The IRR, even though in real terms, is not impressive given the risk. On financial grounds, the line of credit is therefore probably not a good investment.

C.2.2 Economic Appraisal

C.2.2.1 Investment Costs. We have broken down investment costs into local currency and foreign currency. The local currency item, however, contains an element of import duty on capital goods. Poyais' rate of import duty on capital goods varies between 0% and 20% of the c.i.f. price (i.e., of the foreign currency component of investment). Taking the average rate of duty as 10%, this means that the import duty payable in each of years 1 to 3 is expected to be 0.3 million pesos. Because this amount is a transfer item, it should be subtracted when undertaking the economic appraisal.

No information was available on the unskilled labor component of the investment costs. Unskilled labor arises only in the construction and civil works aspects of investment, which varies greatly from project to project. Moreover, the use of unskilled labor varies greatly from one contractor to another, some preferring to use capital-intensive methods wherever possible. Given these uncertainties, it was decided that there was no basis for separating the unskilled labor component from investment costs.

C.2.2.2 Working Capital. The division of working capital into local currency and foreign currency was made earlier, and further adjustment was not considered necessary.

C.2.2.3 Operating Costs, Labor, and Sales Revenues. As the subprojects were to involve the agricultural, agricultural processing, and manufacturing sectors, it is reasonable to assume that all the outputs will be exports or import substitutes. In other words, they will be traded. Much of the inputs, too, will consist of nontraded items such as transport, power, and services, and there will be an unskilled labor element. The problem is to ascertain whether reasonable average figures could be obtained for nontraded items and unskilled labor, and whether ratios for nontraded items and unskilled labor to capital costs (or to profit before tax and interest) could be estimated.

For labor, the task proved to be relatively easy. From national income and expenditure accounts, estimates of the capital stock and employment figures gave an overall capital/labor ratio of about 10,000 pesos per job. Second, an analysis of some recent BANDESSA subprojects was conducted, taking the value of initial investment and the number of unskilled workers currently employed by these enterprises. The figure of investment per job created turned out to be 11,750 pesos, which is not far removed from the overall national figure. However, the figures varied considerably between sectors, as follows:

Sector	Investment/Job Created
Agriculture	4,000 pesos
Agricultural Processing	16,667 pesos
Manufacturing	3,629 pesos

The variation was so marked that it was considered prudent to take it into account. The number of jobs to be created was estimated as shown in Table C.2-5 on the basis of an investment of $15 million -- the amount to be invested in each of years 1 to 3.

Table C.2-5

Estimated Number of Jobs Created by Sector

Sector	% of Investment	Investment (million pesos)	Investment/Job (pesos)	No. of Jobs
Agriculture	20	3.0	4,000	750
Agricultural Processing	50	7.5	16,667	450
Manufacturing	30	4.5	3,629	1,240
Totals	100	15.0		2,440

The number of jobs to be created in each of years 2 to 4 (we assume labor is taken on after the one year of construction) includes managerial, professional, clerical, and skilled manual labor as well as unskilled labor. It is, of course, difficult to break down the total into these different categories of labor, but national employment statistics suggested that 75% to 80% of those employed are in unskilled or semiskilled jobs. These are the sorts of jobs for which it would be appropriate to use a shadow wage. Therefore, as a rough guide, a figure of 2,000 semiskilled and unskilled jobs to be created in each of years 2 to 4 would probably be realistic.

The next task is to estimate a wage bill, so that a shadow wage can be applied. Wage rates vary from job to job and from area to area, but in the absence of more detailed information about the projects, the only realistic course of action is to use an average national wage for unskilled and semi-skilled labor. Information from Poyais' labor department suggested that this was approximately 2,000 pesos. Therefore, the estimated wage bill in year 2 is 4 million pesos, in year 3 is 8 million pesos, and in year 4 is 12 million pesos, when full employment under the scheme is reached. When completing Chapter 3's Worksheet 6, the wage bill must be added back to the net profit before interest and tax to calculate the gross benefit and then included again as a cost, so that it can be shadow-priced conveniently.

The problem of estimating what nontraded items might cost proved impossible. Clearly, some significant inputs such as transport, power, and water, appear on the cost side. However, they vary widely from one project to another, and any estimate is likely to be substantially inaccurate. They may also appear on the output or benefit side, to the extent that outputs are nontraded. This may happen when investments are made in service industries or in industries which produce goods which are effectively nontraded, such as certain construction materials or soft drinks. Therefore, the impact of nontraded items will, to some extent, cancel each other out. In most cases, it is probably reasonable to assume that the whole of the net profit before interest and tax, apart from labor, can be treated as wholly traded. If, therefore, we add back the estimated labor costs to the net profit before interest and tax in Worksheet 6, we get a figure for benefits which is entirely traded, or in other words foreign exchange benefits.

C.2.2.4 National Parameters (SER, SWR, OCC). For the purposes of this case study, it was assumed that these national parameters were provided by the Ministry of Economic Planning having values of:

Shadow exchange rate	1.2
Shadow wage rate	0.7
Opportunity Cost of Capital	8.0%

C.2.3 Summary of the Economic Appraisal

It is now possible to complete the benefits and costs summary; dividing the net benefits into local currency items, foreign currency items, and labor; and applying shadow prices. The net benefits with shadow pricing can then be discounted to give a economic rate of return of 22%, which compares favorably with the opportunity cost of capital of 8%. The line of credit, which appeared to give an indifferent financial rate of return, gives a very acceptable economic rate of return, after shadow pricing.

It must be emphasized that the methodology applied here is very crude, and that the calculated rates of return must be interpreted accordingly. Nonetheless, the difference between the economic rate of return and the opportunity cost of capital is sufficiently large to give considerable confidence that the national economic benefits will be sufficient to justify the line of credit.

In Worksheet 6, no salvage values have been included. It is assumed that year 1 investments stop producing at the end of year 11, year 2 investments at the end of year 12, and year 3 investments at the end of year 13. Similarly, no replacement investments (e.g., for vehicles) have been included in the intermediate years.

It is assumed that operating labor for year 1 investments is taken on at the start of year 2, that for year 2 investments at the start of year 3, and for year 3 investments at the start of year 4. It is also assumed that labor is laid off after 10 years of operation.

The import duty of $0.3 million has been added back to the (negative) investment costs. This has been treated as a correction to foreign currency because it was included in the investment amount used in the financial analysis.

Worksheet 6

Economic Benefits and Costs Summary
(million pesos)

	Years						
	1	2	3	4	5-11	12	13
Benefits							
Net profit before interest & tax	-	-	3.38	6.76	10.14	6.76	3.38
Add back labor	-	4.00	8.00	12.00	12.00	8.00	4.00
Total:							
Foreign currency	-	4.00	11.38	18.76	22.14	14.76	7.38
Costs							
Investment:							
Local currency	-12.00	-12.00	-12.00	-	-	-	-
Foreign currency	-3.00	-3.00	-3.00	-	-	-	-
Elimination of import duty	0.30	0.30	0.30	-	-	-	-
Working capital:							
Local currency	-3.66	-3.66	-3.65	-	-	-	-
Foreign currency	-1.22	-1.22	-1.21	-	-	-	-
Operating Costs:							
Labor	-	-4.00	-8.00	-12.00	-12.00	-8.00	-4.00
Net Benefits							
Local currency	-15.66	-15.66	-15.65	-	-	-	-
Foreign currency	-3.92	0.08	7.47	18.76	22.14	14.76	7.38
Labor	-	-4.00	-8.00	-12.00	-12.00	-8.00	-4.00
Net Benefits with Shadow Pricing							
Local currency	-15.66	-15.66	-15.65	-	-	-	-
Foreign currency	-4.70	-0.10	8.96	22.51	26.57	17.71	8.86
Labor	-	-2.80	-5.60	-8.40	-8.40	-5.60	-2.80
Total Net Benefits with Shadow Pricing	-20.36	-18.36	-12.29	14.11	18.17	12.11	6.06

Economic Internal Rate of Return = 22%
Net Present Value at 8% Discount Rate = 42.6 million pesos
Discounted Benefit-Cost Ratio = (not applicable in this case)

Shadow Exchange Rate (SER) = 1.20
Shadow Wage Rate (SWR) = .70

4.5 Training and Education Sector

Because it is widely believed that an essential element of economic development is upgrading the skills of a country's work force, assistance programs to developing countries often include training and education. Such programs may deliver any or all of the following: primary and secondary general education, post-secondary general and specialized education, and basic and advanced vocational training.

4.5.1 Assessment of Benefits and Costs

The quantification of the benefits of education programs typically proceeds along one of two universally accepted paths. First, one can estimate the incremental lifetime earnings of the students/trainees participating in the program. This approach implicitly accepts national income as a reasonable measure of aggregate social welfare. The second approach is cost-effectiveness analysis. Here, the least-cost method of delivering a given education program is sought. The use of cost-effectiveness analysis circumvents the problem of estimating the monetary benefits of education. However, cost-effectiveness analysis does not help determine whether an education program is worthwhile. It determines only that one program or another is less costly (or more efficient), given that some education program is desirable. Although cost-benefit and cost-effectiveness analyses are complementary, and thoroughness might dictate that both be carried out in evaluating a program, in practice only one or the other typically is utilized in a given case. This is an area in which conventional practice can use improvement.

The estimation of incremental lifetime earnings is fraught with difficulties. "The calculation of differential lifetime earnings is inherently a very speculative and risky exercise, subject to a wide margin of possible error. A change in any one of the key assumptions could alter the results considerably" Arigazzi (1972, p. 351). Some of the more important assumptions typically needed include:

1. Numbers of students/trainees enrolling annually.

2. Completion or graduation rates.

3. Placement and promotion rates. That is, what percent of trained work force entrants will find a job commensurate with their skill level? What percent of workers with existing jobs will be promoted to higher skill jobs?

4. Whether, or to what extent, trained workers displace or supplement untrained workers among the ranks of the employed.

5. The unemployment rate, over time, of trainees.

6. Wage rates for various jobs, over time.

7. The baseline: what incomes will trainees earn if they do not complete the program.

8. The initial and ongoing costs of the program.

Because reliable data on wages and employment are frequently unavailable in developing countries, it is difficult to develop defensible projections of wage rates, employment opportunities, and unemployment rates in most cases.

As Arigazzi (1972, pp. 333-334) states "in trying to compute the costs and benefits of an educational project a host of variables must be considered. There are never enough solid facts for the purpose. Worst of all, many of the costs to be measured and virtually all of the benefits lie somewhere off in the future and can only be approximately estimated now. Thus, to do a cost-benefit analysis, one must be willing to strip the real-life situation to its simplest dimensions -- in short, to oversimplify it -- and then to rough in factual gaps with plausible assumptions, estimates, and guesses, thereby risking predictions which later may prove to be wrong."

4.5.2 An Example

As an example of how a training program can be evaluated, consider the following hypothetical case. A program to train workers to assemble electronic components is established at an initial cost of 100,000 pesos and an ongoing annual cost of 40,000 pesos. The program is budgeted to last for six years including the one-year start-up, at which time it may be renewed if warranted. The program can accept and train a maximum of 300 students per year. Students who successfully complete the program and find work in their new field can expect earnings of 1500 pesos per year. This compares with 1,000 pesos per year expected earnings without the training. The 500-peso differential is expected to persist over time, in real terms, regardless of inflationary effects.

The program is designed for recent high school graduates in the 18-24 age group. Although these students have expected working lives of approximately 40 years, it may be overly optimistic and unduly speculative to project differential earnings to the year 2025 and beyond. Instead, a conservative approach using a 10-year time horizon is adopted; i.e., we assume the differential earnings effect for any trainee lasts 10 years.

We assume that 300 students per year are enrolled and that 80% successfully complete the program. Of the 80%, we project that 75% will find permanent work in their new field.

The social costs of the training program include not only the 100,000 pesos start-up and 40,000 pesos annual costs, but also the direct costs to the students of tuition, books, and living expenses of 200 pesos; and the opportunity cost of lost income of 1,000 pesos per student (assuming all would otherwise be employed -- a conservative assumption) while attending the program for a year.

The costs of the program can be estimated and summarized as follows:

Year	Cost	Comment
1	100,000	Start-up costs
2-6	40,000	Ongoing program costs
	60,000	Direct student expenses
	300,000	Student opportunity costs

Using a discount rate of 8%, the present value of costs is:

$$\frac{100{,}000}{1.08^1} + \frac{400{,}000}{1.08^2} + \frac{400{,}000}{1.08^3} + \frac{400{,}000}{1.08^4} + \frac{400{,}000}{1.08^5} + \frac{400{,}000}{1.08^6}$$

= 1,571,374 pesos

The benefits of the program can be estimated and summarized as follows:

Year	Benefits	Calculations
1	0	
2	0	
3	90,000	(300 x 80% x 75% x 500)
4	180,000	(300 x 80% x 75% x 500) x 2
5	270,000	(300 x 80% x 75% x 500) x 3
6	360,000	(300 x 80% x 75% x 500) x 4
7-12	450,000	(300 x 80% x 75% x 500) x 5
13	360,000	(300 x 80% x 75% x 500) x 4
14	270,000	(300 x 80% x 75% x 500) x 3
15	180,000	(300 x 80% x 75% x 500) x 2
16	90,000	(300 x 80% x 75% x 500)

Benefits first accrue in year 3 as the class trained in year 2 begins to earn the salary differential. In year 4, benefits accrue to the classes trained in years 2 and 3. In year 5, benefits accrue to classes 1, 2 and 3; and so on. According to our

assumption that the effects of training last 10 years, all 5 classes accrue benefits in years 7 through 12. In year 13, only classes 2 through 5 accrue benefits. In year 14, only classes 3 through 5 accrue benefits, and so on.

The present value of the benefits is calculated as the sum of the discounted benefit stream and results in a value of 2,232,617. Therefore, the net present value of the training program is:

Discounted Benefits	=	2,232,617 pesos
Discounted Costs	=	-1,571,374 pesos
Net Present Value	=	661,243 pesos

Self-selection, wage distortions, and externalities are three types of bias which may taint estimates of incremental lifetime earnings. The self-selection bias arises when more highly motivated individuals join the training programs. Such individuals are more likely to have higher than average future incomes even without the training programs. Thus, ascribing baseline "expected" incomes to this group will tend to overstate the contribution of the training program.

A wage distortion refers to any situation in which the wage received differs significantly from the value of the marginal product produced by the worker. Such distortions can arise from several sources. For example, national minimum or other "administered" wage policies or artificial job entry barriers may cause prevailing wages to differ from the value of workers' output. This would cause a bias in benefit estimation if the benefit calculations were based on the prevailing market wage structure. If such distortions are considered substantial, then a shadow pricing approach may be called for.

It is widely recognized that the private and social benefits of training and education extend beyond incremental lifetime earnings. "...greater earnings are not the only benefits to be derived from further education. Indeed, increased earnings may not even be the most important payoff of education. For the individual, increased education may enhance his capacity to appreciate the finer things in life, to talk intelligently and live graciously; in short, to enjoy the litanies of education so frequently chanted in humanistic philosophy by the well-educated. For society, education has many externalities ranging from an informed citizenry to better police-community and interracial relationships. No study has been able to incorporate or monetize all these diverse benefits and spillovers of education." Clark and Fong (1970, p. 163.) The presence of nonmonetary private as well as social benefits would suggest that estimates of incremental lifetime earnings represent an understatement of the value of training and education.

Cost-effectiveness analysis seeks to determine the least cost and most efficient education program among a specified set of programs or alternatives. There are three variations of cost-effectiveness analysis:

- finding the least-cost alternative among a set of alternatives which achieve a given level of benefits,
- finding the program with greatest benefits among a set of alternatives with equal costs, and
- finding the program with the best trade-off of benefits and costs among a set of alternatives with different costs and different benefits.

The major difference between cost-benefit analysis and cost-effectiveness analysis is the monetization of benefits. The former attempts it, and the latter does not. In a cost-effectiveness analysis, benefits may be quantified as, for example, numbers of students trained or number of student-years training provided. The cost-effectiveness analysis criterion could be cost per student or cost per student-year.

In practice, analysts frequently find that a credible CBA of a training or education program is not feasible due to the difficulty of monetizing benefits. For this reason, cost-effectiveness analyses frequently supplant cost-benefit analyses in the economic evaluation of training and education programs.

The estimation of the costs of training and education programs is no different from cost estimation in other areas of application of cost-benefit analysis. Costs can be divided into "start-up" and "operations" phases. Each phase encompasses labor, capital, materials, and so on. Of course, a life-cycle cost philosophy should be adopted. One important cost category not to be overlooked is a student's or trainee's opportunity cost of attendance. If attendees would otherwise be productively employed, then attendance constitutes a real private and social cost which must be reflected in the economic analysis.

What results have been found in past studies of the value of training and education? Table 4.5-1 summarizes six published studies. The internal rates of return range from 0 to 50%. Clearly, generalizations about "standard" or "normal" rates of return cannot be made based on these results. Each case must be evaluated on its own merits.

Table 4.5-1

Selected Reported Social Returns to Training and Education

Author(s)	Country	Data	Type of Training/Educ	IRR	Notes
1. Arigazzi	Chile	1965	Vocational	45-50%	
2. Clark & Fong	Singapore	1966	Primary	8% or more	1
			Secondary	15% or more	1
			Post-secondary	15%	1
3. Johnson & Thomas	U.K.	1980-85	Self-employment	19.5%	
4. Magnusson	Sweden	1968	Post-secondary	0 to 9%	2
5. Psacharopoulos	Developing	Pre 1973	Post-secondary	14.9%	2
	Developed	Pre 1973	Post-secondary	9.3%	
2					
6. Smith	Australia	1969	Post-secondary	.6 to 2.3	3

Notes:
1. Males with no previous job training.
2. IRR depends on curriculum. Values given are averages.
3. Value in IRR column is benefit/cost ratio.

REFERENCES

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GLOSSARY OF TERMS AND PHRASES

This section defines key terms and phrases used in the manual. The definitions are specific to the usage in this manual and, therefore, may not be precisely the same as found in an economic dictionary.

Abundant labor

When substantial unemployment and underemployment exists, labor is said to be in abundant supply. The term usually refers to unskilled labor in economic analysis and is the labor category that requires shadow pricing.

Annual equivalent cost

A measure of project worth. Investment costs are annualized using the social discount rate and then added to operating costs to arrive at an annual total cost spread over all years of the planning horizon. These figures are usually expressed as per-unit costs by dividing the annual equivalent cost by average annual output.

Benefit-cost ratio

As an undiscounted measure, this ratio is the sum of annual benefits divided by the sum of annual costs. As a discounted measure the annual stream of benefits and costs are discounted by the social discount rate before summing. If the ratio is greater than one, the project will return benefits over and above the costs it incurs.

Benefits

In project analysis, any good or service produced by a project that advances the project's objective. Benefits are any goods or services that increase the income of the entity in financial analysis or increase the national income of the society in economic analysis.

Black market

A term used to describe an illegal market in some good or service. In project economic analysis, a "black" market usually refers to an illegal market in foreign exchange. Because of the competitive nature (lack of governmental controls) of black markets in foreign exchange, the rate of exchange in this market is sometimes used to measure the premium attached to foreign exchange in developing countries.

Border price

The unit price of an export (f.o.b. price) or an import (c.i.f. price) at a country's international border. Also referred to as the world price of the good in question.

Boundary price

In this manual, the project boundary price refers to the price paid for an input or received for an output at the boundary of the project. In agricultural projects, the term "farm-gate" price refers to the price the farmer receives for his product, which may or may not be the project boundary. If the project entails a marketing component, the farm-gate price and project boundary price are distinctly different, because the latter includes the marketing component.

C.i.f.

C.i.f. is an abbreviation for cost-insurance-freight or charged-in- full. It refers to the price of a traded commodity being imported. As the term implies, the c.i.f. price includes the original cost of the commodity at the foreign port (the f.o.b. price at that port) plus any insurance and freight costs getting the commodity to the importing country's port. It excludes tariffs and taxes imposed by the importing country.

Construction phase

The time period where all construction for the project takes place.
It is usually the period in the cash flow table where investment costs are shown and no benefits accrue since the project has not yet reached a stage where the output of the project can be realized.

Consumer surplus

The difference between the total amount of money a consumer would be prepared to pay for some quantity of a good, and the amount he actually has to pay. In economic analysis, consumer surplus is a consideration when the output of the project causes the market price of the product to fall. Those consumers previously paying the higher, old price (what they are willing to pay) will reap a benefit (consumer surplus) from the lower, new price which must be added to the benefits accruing to the new consumers.

Conversion factor

Usually less than 1.0, a conversion factor corrects distortions in domestic prices from trade distortions. Multiplying the factor times the domestic price of a good or service converts the price to an equivalent border (world) price. The use of conversion factors in economic analysis is theoretically equivalent to adjusting the price of traded goods and services with the shadow exchange rate.

Cost-benefit analysis

The analytical technique used to appraise projects with quantifiable benefits and costs over a finite planning horizon.

Cost-effectiveness analysis

A project appraisal technique used in lieu of cost-benefit analysis when benefits cannot be reasonably measured in money terms. The aim is to minimize costs while maximizing effectiveness. Used primarily in health, education, and nutrition sectors where benefits are difficult to assess in monetary terms.

Costs

Costs are goods or services used in a project that reduce the benefits of the project. A good or service used in a project that reduces the national income of the society.

Cross-over values

The same as switching values used in sensitivity analysis. The value of an element of the analysis that just causes net present value to be zero.

Debt service

Payments made by a borrower to a lender. The payments may include one or all of: (1) payment of interest; (2) repayment of principal; (3) loan commitment fee.

Depreciation

The anticipated reduction in the value of an asset over time that is brought about through physical use or obsolescence. In accounting, depreciation refers to the process of allocating a portion of the original cost of a fixed asset to each accounting period so that the value is gradually used up ("written off") during the course of the asset's estimated "useful life."

Discount rate

The interest rate used to determine the present value of a future value by discounting. In this manual, the opportunity cost of capital is taken as the discount rate.

Diverted export

A project input that would have been exported in the absence of the project.

Economic lifetime

The period during which a fixed asset is capable of yielding services to its owner. Distinguished from "physical life," a period often longer, during which a fixed asset can continue to function notwithstanding its obsolescence, inefficient operation, high cost of maintenance, or obsolete product.

Export parity price

The f.o.b. price of an export or diverted export adjusted for domestic costs between the project and the point of export.

Externalities

In project analysis, an effect of a project felt outside the project and not included in the valuation of the project. In general, economists consider an externality to exist when production or consumption of a good or service by one economic unit has a direct effect on the welfare of producers or consumers in another unit.

F.o.b.

An abbreviation for free-on-board. The price of an export loaded in the ship or other conveyance that will carry it to foreign buyers.

Final physical output

A quantifiable output of the project to which a valuation has been estimated and entered into the project accounts. May be a benefit or cost.

Foreign component

Designates the foreign currency amount of a benefit or cost in the Economic Benefit-Cost Flow Statement (Worksheet 5). It is separated from local costs and labor costs shadow priced in Worksheet 5 for shadow pricing with the shadow exchange rate.

Foreign exchange premium

The proportion by which the official exchange rate overstates the real value of local currency or of nontraded goods and services relative to traded goods and services. If the shadow exchange rate is 1.20, then the premium is 20%.

Full operation phase

The period in the planning horizon where the project is producing benefits at full capacity.

Home consumption

In project analysis, goods and services that are produced on a farm and consumed by the farm family. Represents a form of wage and should be a part of the shadow wage rate calculation.

Impact transmission mechanism

The causal chain of events (impacts) from a physical input or output of a project. An impact, e.g., from the use of an input, is transmitted through the economy in a series of cause and effect relationships (transmission mechanism), which must be identified for proper accounting of all changes to national income that result.

Import parity price

The c.i.f. price of an import or import substitute adjusted for domestic costs between the project and the point of entry.

Import-substitution

An output of a project that replaces goods or services that would have been imported without the project.

Incremental net benefits

The change to national income resulting from the project. Net benefits with the project minus net benefits without the project.

Intangible

In project analysis, refers to a cost or benefit that, although having value, cannot realistically be assessed in actual or approximate money terms. Examples of intangible benefits include health, education, employment generation, electricity for home lighting, and the value of domestic water supply. Intangible costs are often the absence of the related benefits -- disease, illiteracy, and so forth -- but may also be such items as environmental degradation, inconvenience, and the like.

Intermediate physical output

An output of a project that does not complete the project objective. When the benefit of the project cannot be realized without first producing some other output (reduced birth rate cannot be realized without first producing contraceptives), where the other output is considered to be an intermediate physical output.

Internal rate of return

A discounted measure of project worth. The discount rate that just makes the net present value of the incremental net benefit stream, or incremental cash flow, equal zero. The maximum interest that a project can pay for the resources used if the project is to recover its investment and operating costs and still just break even.

Internalized

When an externality is quantified in money terms and added to the project accounts, it is said to have been "internalized."

Investment costs

The expenditure on resources for a productive activity from which an income is expected to flow at a future time. Primarily occurs during the construction phase of a project and consists of fixed capital, working capital, and replacement capital (expended over the life of the project).

Investment criteria

Measures of project worth such as net present value, internal rate of return, and benefit-cost ratio.

Local component

In Worksheet 5 of this manual, the component of a cost or benefit that concerns only domestic goods or services, except labor costs subject to the shadow wage rate which are broken out as the "Labor" component.

Magnitude analysis

A quick cost-benefit analysis performed with limited data for the purpose of assessing the initial feasibility of a proposed project. Can be used to see if a realistic price for the project's output will generate enough revenue to cover expenses.

Marginal value product

The value of additional output generated by an additional unit of variable input.

Market prices

A price at which a good or service is actually exchanged for another good or service (as an inkind payment) or for money (in which case it is a financial price).

Net benefits

For each accounting period, the difference between benefits and costs.

Net present value

A discounted measure of project worth. The present value of the incremental net benefit, or incremental cash flow, stream of a project. The difference between the present value of the benefits and the present value of the costs of a project.

Nontraded

A project input or output that is not traded across the national boundaries of a particular country.

Official exchange rate

The rate, established by the monetary authorities of a country at which domestic currency may be exchanged for foreign currency.

Operating costs

The variable and fixed costs incurred in producing the output of a project in a single accounting period.

Opportunity cost

The benefit forgone by using a scarce resource for one purpose instead of for its next best alternative use.

Payback period

An undiscounted measure of project worth. The time from the beginning of the project until the net (undiscounted) incremental production stream totals the amount of the (undiscounted) investment of capital.

Pecuniary externalities

When the project affects prices outside the project boundary. For example, a decrease in the price of bread due to an expanded, lower priced, wheat production.

Physical contingencies

An amount included in a project account to allow for unforseen costs associated with physical phenomenon such as higher rock content encountered in the excavation phase of a construction project.

Physical input

Any good or service used in the project's production process of a physical output.

Physical output

Any intermediate or final good or service produced by an activity of the project.

Planning horizon

The time period covered by the project analysis. Covers the construction, start-up, full operation, and terminal year phases.

Price contingencies

An amount included in a project account to allow either for inflation or for an expected increase in relative prices of particular inputs. Inflation contingencies excluded from financial and economic analysis when the analysis is done in constant prices, but relative-price contingencies included.

Production function

A mathematical relationship between the quantity of output of a good and the quantity of inputs required to make it. For use in this manual, the phrase refers to the activity of a project where inputs are consumed to produce some desired level of output.

Project boundaries

The extent of the activities included in the project accounts. Derives from the concept of the physical boundaries of a project, but is extended to allow for projects that do not have fixed geographical boundaries but rather may have a combination of participants in various geographic locations.

Project definition

The objectives of the project relative to the national goals of the country, what markets the project will affect, and the boundaries of the project.

Project economic analysis

An analytical system that compares costs with benefits to determine if a proposed project, given the alternatives, will advance the objective of society sufficiently to justify undertaking the project.

Replacement investment

Expenditures during the full operation phase for replacement of worn out equipment.

Residual value

The value of an asset remaining unused at the end of a project. The same as terminal value.

Risk analysis

An analytical technique in which probabilities of occurrence are determined for all critical project elements and then, by computer, repeated computations of a measure of project worth are made, each element entering in successive computations according to its probability of occurrence.

Rural wage

In this manual, it refers to an estimate of the marginal value product of an agricultural worker. It is often used as the shadow wage rate in economic analysis.

Sensitivity analysis

An analytic technique to systematically test what happens to the earning capacity of a project if events differ from the estimates made about them in planning. A means of dealing with uncertainty about future events and values. A sensitivity analysis is done by varying one element or a combination of elements and determining the effect of that change on the outcome, most often on the measure of project worth.

Separability

The ability of different components of a project to stand on their own. Separating a project into two or more components and then analyzing the viability of each component.

Shadow exchange rate

The official exchange rate plus the foreign exchange premium. If expressed as a ratio, then it is the official exchange rate multiplied by 1 plus the foreign exchange premium (as a fraction).

Shadow price

The value used in economic analysis for a cost or a benefit in a project when the market price is felt to be a poor estimate of economic value. Technically, a shadow price is derived from a complex mathematical model, e.g., a linear programming model. Sometimes called efficiency price.

Shadow wage

The shadow price for abundant labor. In this manual, it is the same as the rural wage and estimated by the marginal productivity of the agricultural worker.

Skilled labor

Usually designates scarce labor in developing countries. The market wage for skilled labor is thought to accurately reflect the opportunity cost of this labor class and therefore, skilled labor is usually not shadow priced.

Social discount rate

A rate that expresses the preference of a society as a whole for present returns rather than future returns. Used in economic analysis to discount the incremental net benefit stream.

Start-up phase

The phase of a project where the productive process is tested at less than full operation.

Sunk costs

A cost incurred in the past that cannot be retrieved as a residual value from an earlier investment. A sunk cost is not an opportunity cost and thus is not included among the costs when a proposed project or other investment is analyzed.

Switching values

The value an element of a project would have to reach as a result of a change in an unfavorable direction before the project no longer meets the minimum level of acceptability as indicated by one of the measures of project worth. The value of an element of a project that results in a net present value of zero for the incremental net benefit stream. Same as cross-over values.

Tangible

In project analysis, a cost or benefit that is capable of being appraised at an actual or approximate price or economic value.

Technological externalities

An impact from the project on the environment that causes a loss or gain to some entity in the society. Outside the project boundaries but caused by either the supply of inputs, the production process, or consumption of outputs.

Terminal value

The value of an asset remaining unused at the end of a project. Also called residual value.

Traded

A project input or output is traded if its production or consumption will affect a country's level of imports or exports on the margin.

Transfer payments

A payment made without receiving any good or service in return. A "direct" transfer payment occurs when a payment is made that directly shifts claims to goods and services from one entity to another entity in the society. All transfer payments are excluded in economic analysis.

Unskilled labor

In economic analysis, usually refers to abundant labor whose project wage does not reflect the opportunity cost of using the labor. Unskilled labor is shadow priced to adjust for this difference in actual wage and the opportunity cost of the labor.

Willingness to pay

The amount consumers are prepared to pay for a final good or service. An estimate of the value in use.

With/Without

The central principle in performing project appraisals which examines the economy and environment over the planning horizon both with and without the project. The "without" project appraisal takes account of what can be expected to occur in the absence of the project, i.e., what change in net benefit will occur without the project.

Working capital

The capital necessary to purchase goods and services that are used for the production activities of an enterprise during the production period between the purchase of inputs and receipt of sales.

World price

The price of good or service traded in international markets. The f.o.b. price of an export or the c.i.f. price of an import -- the border price of goods and services.

ANNEX

COST-EFFECTIVENESS ANALYSIS

Cost-effectiveness analysis (CEA) is an approach to project appraisal in which project benefits or costs are identified, but only the costs are monetized. Unlike traditional cost-benefit analysis, no attempt is made to place a monetary estimate on project benefits. This happens because project benefits may be very difficult to quantify (e.g., improved aesthetic conditions from a civic beautification program or changes in lifetime earnings from an educational development project) or difficult to value (e.g., health effects from a primary health care project, improved air quality from a pollution control project, or changes in quality of life from a rural electrification project).

CEA is particularly useful where benefits are hard to quantify or value due to lack of data or insufficient knowledge about cause and effect relationships. Many AID projects that deal with human resource development in the health, education, or family planning areas may be evaluated by means of CEA.

CEA can take three basic forms:

- minimizing costs for a given level of effectiveness (a form of least-cost analysis);
- maximizing effectiveness for a given level of cost; and
- finding the best trade-off between costs and effectiveness.

The first criterion requires that the planner first set a goal and then the economist examines different means of achieving that goal. The goal may be a social goal (increased average number of years of schooling for children), a health goal (reduced infant mortality rate), or an environmental goal (reduction of water or air pollution by a certain amount).

The second criterion assumes that a predetermined level of funding is available for a certain area (e.g., child health care); the analyst then examines a number of alternative ways of using the money. In the case of child health care these could include nurse training, supplementary feeding, oral rehydration programs, or expanded maternal and child health (MCH) facilities. The analysis

then estimates the effectiveness of each alternative in improving child health care, in this case evaluated by some measure such as the infant mortality rate or weight for height measures.

The third criterion combines elements of the first two. The analyst considers a number of goals, examines the differences in the cost of achieving them, and then decides which goal seems most reasonable considering the costs involved.

CEA has been applied to many different types of projects. Three examples are given here: an education program, an immunization program, and an environmental pollution reduction project (Dixon et al. 1986).

Education:

In the evaluation of an education project, a CEA is useful for comparing the relative merits of several similar projects. Unlike cost-benefit analysis, however, it is not useful for determining their absolute desirability.

If there were two alternative education projects under consideration, it might be possible to do a conventional cost-benefit analysis based on projections of the net incremental lifetime earnings under the two scenarios. Frequently, however, such a determination is very difficult to make; establishing a cause and effect relationship may require more data than are available. A CEA, on the other hand, would evaluate the two projects in terms of, for example, student-years of education provided or student achievement levels.

Continuing with the example of education projects, if a CBA were possible and determined that annual benefits were $10 million and annual costs were $6 million for Project I, and that annual benefits were $8 million and annual costs $5 million for Project II, we could legitimately infer that Project I is superior to Project II -- it has a higher benefit-cost ratio. And we could further infer that Project I is worth carrying out, and that if sufficient funds were available and if the two projects were not mutually exclusive (that is, doing one project would not preclude also undertaking the other project), Project II would be worth doing as well. Both projects yield benefits that are larger than the costs involved.

If a CEA were performed rather than a CBA, we again would find that the annual costs of Projects I and II would be $6 million and $5 million, respectively. We might also find that 10,000 students per year would be educated under I and 8,000 per year under II. The cost-effectiveness ratio for the first program would be $600 per student and for the second program $625 per student. We could infer that Project I is more cost-effective than Project II. However, we

could not infer that Project I is, in fact, worth doing. (Perhaps the value of the education received is only $300). The CEA results would be useful if the decision were between only alternatives I or II.

The more traditional cost-benefit analysis results would be needed if the decision were among the four possible choices: carry out Project I, Project II, Projects I and II, or neither.

Immunization:

Another example of a cost-effectiveness analysis is a case study prepared for the USAID in-house financial analysis training course (Cost-effectiveness Study of Immunization Strategies in Motapia, April, 1987). The case describes in some detail the use of CEA to compare three principal vaccination strategies that are in use throughout the world -- routine services provided by fixed centers (referred to as PMIs in the study), routine services provided by mobile teams, and mass campaign in selected urban cities (MC). Based on actual data, the study presents the case of the hypothetical country of Motapia.

When an immunization strategy is described as 'cost-effective', it means that in comparison to another strategy, current levels of immunization can be achieved at lower cost, or that the particular program in mind achieves greater coverage at no additional cost. Cost-effectiveness analyses are employed usually as a way of monitoring the performance of immunization programs from the perspective of maximizing the use of scarce health resources. The components of cost identified in this type of analysis can be used as a reference for finding ways of reducing the overall cost of programs. The evaluation of coverage inherent in this analysis can point to ways of improving the impact of a particular immunization program. These two components together serve as the foundation for recommendations to improve a program's cost-effectiveness.

The costs for each strategy include direct and indirect expenses incurred during planning, implementation, and operation. Costs were divided into recurrent costs and capital investments. Recurrent costs include those for personnel, transport, training, supervision, management, supplies, vaccines, and media cost. Capital investments include purchases of buildings, vehicles, cold chain equipment, and medical equipment.

The results of this study are summarized in Table 1 at the end of the Annex. The major differences in costs between alternatives is striking; mobile teams, in part due to high equipment, fuel and personnel costs, are by far the most expensive alternative, both overall and in terms of cost per completely vaccinated child (CVC). The health center cost was $6.83 per CVC while mobile teams cost almost three times as much -- $17.37.

Table 1 also has information on marginal or incremental costs of completely vaccinating one child above and beyond those reached by the reference alternative, the PMI health centers. This analysis shows that the incremental cost-effectiveness ratio of the mass campaign (MC) alternative was higher, $10.96 per CVC as compared to $6.83 for the reference PMI alternative. The mass campaign had clearly higher costs but was able to reach a larger number of children, especially those 0-5 years of age. Note that reaching very young children (0-1 year old) is both difficult and expensive. The reasons for this are explained in the full case study.

In this case a CEA gives clear guidance when evaluating three commonly used alternatives for immunizing young children. Note that no discussion is presented on the benefits of immunization; the implicit assumption is that the benefits are larger than the costs.

Environment:

In the third case, that of an environmental pollution reduction program, the first step is deciding upon a target to achieve. For example, in the environmental field this may be a certain ambient air quality, a maximum level of exposure to a waterborne disease agent, or an emission standard for industrial facilities. Setting the standards at appropriate levels in these cases is important. The policymaker must consider the trade-offs among different standards and the costs associated with achieving them. The standard economic principle that is normally appied to this kind of decision is the equating of marginal costs with marginal benefits. However, when benefits are difficult or impossible to measure the value of this approach is reduced to being primarily conceptual.

Technology may dictate the available alternatives; as standards become more stringent, there may be only a few alternative control strategies with each providing a given level of pollution reduction at a certain price. Analyzing the incremental cost of adopting one control strategy over another may provide a clear indication of the sensible strategy. In cases where there are many alternatives from which to choose, choosing the standard may be more difficult. (See Hufschmidt et al., 1983 for examples of this approach to setting industrial pollution standards.)

Once a target or standard is chosen, the cost-effectiveness analysis is performed by examining the various ways of reaching this target. This may involve analyzing the capital and operating costs of different control technologies. In other projects, various management practices may be the decision variable subject to change. Each project will involve different alternatives and must be dealt with differently. Analysts must ensure that a wide range

of alternatives are considered but the basic goal is the same -- identify the least-cost atlernative available for meeting a given goal.

Although cost-effectiveness analysis appears to be a straight-forward economic (and engineering) approach, in practice there is a wide scope for careful analysis. One of the main reasons for this is that frequently the various alternatives may reach different levels of control. For example, if the "target" level is an emission standard of no more than 100 ppm and there are three technological alternatives, A, B, and C, the analysis may yield the following information:

Alternative	Cost to Install (million $)	Emission Level (ppm)
A	50	98
B	15	135
C	25	105

Alternative A is the only one that meets the set standard; Alternative B is much cheaper to install but clearly does not meet the standard. Alternative C is the problem. It costs only half as much as Alternative A and exceeds the standard by a small amount. Which alternative is best? A strict regulatory approach might require A to be adopted even though C would save $25 million. Is the slight increase in emissions justified by the savings? The cost-effectiveness analysis should present these alternatives to the decision maker. The choice will depend on the potential dangers from a higher emission level and how much the society can afford (and is willing) to pay to reach certain standards.

Similarly, in the vaccination case study presented earlier, the different strategies had varying efficiencies in reaching certain target groups. For example, even though the mass campaigns were slighly more expensive for reaching children 0-5 years of age, and incremental C/E ratio of $10.96, the MC reached a very large number of such children (over 25,000 versus 12,000 by the PMIs). The decision maker has to decide between a lower-cost, but perhaps slower program through the PMIs, or a more expensive, but more wide-reaching mass campaign. The CEA does not provide an answer; it does, however, point out the alternatives available.

Not discussed previously, but of considerable importance, is the question of how much society is willing, or able, to pay. Since cost-effectiveness analysis does not attempt to estimate the benefits derived from meeting a given standard or goal, it is possible that even the most cost-effective (or least-cost) option of meeting strict standard is still too expensive. This point is not an excuse for doing nothing but rather suggests that perhaps the standard should be relaxed. Cost-effectiveness analysis also can be used in many of these cases. Experience from other countries can be used as a guide to both the desired target levels or standards and the expected costs. Just as 100 percent control of pollutants is usually impossible, control costs that outweigh project benefits are also undesirable. Some general guidelines follow:

(i) Examine target levels in a mix of countries, both developed and developing. What are World Health Organization levels, and how are they determined?

(ii) Evaluate the seriousness of the environmental impact being controlled. Is it life-threatening (e.g., mercury poisoning), a health hazard (e.g., dust and particulates) or merely a nuisance (e.g., certain noise levels)?

(iii) Evaluate the impact of the most cost-effective control option on the financial and economic return of the project. If the preferred choice means that the project no longer is profitable, the decision to either go ahead with the project or control negative impacts has to be reconsidered. What are the likely impacts of less pollution control? What are the implications of cancelling the project? Can lessons be learned from other countries that have faced the same problems?

(iv) Is a compromise solution possible that minimizes environmental damages while still allowing the project, or another project, to be built?

Cost-effectiveness is a powerful tool but one that has to be apaplied carefully. Rigid adherence to an environmental standard that is too strict or inappropriate can result in excessive control costs or even cancellation of a project. This is a luxury that few developing countries can afford. Sensibly applied, however, cost-effectiveness analysis can be helpful in providing environmental protection at a moderate cost while allowing development activities to continue.

In sum, CEA can be a very useful tool when project benefits are hard to quantify or value. In using this approach, however, the analyst must always remember that even the most cost-effective alternative may be too expensive for the results produced. As such common sence and policy guidance both play a role in setting the bounds within which CEA can and should be used.

Table 1 COST-EFFECTIVENESS OF VACCINATION STRATEGIES IN MOTAPIA

Strategies		Cost Total $	Number Vaccinated	C/E (Cost$/CVC)	Incmtal Cost	Incmtal Benefit	Incmtal C/E
PMIs	1	83970.	12297a	6.83	--	--	--
	2		4058	20.69	--	--	--
Mobile Teams	1	357880.	20604b	17.37	--	--	--
	2		2411	148.44	--	--	--
MCs	1	228715.	25507c	8.97	144745.	13210	10.96
	2		2398	95.38	144745.	-1660	-87.20

1 = Children 0-5 year completely vaccinated
2 = Children 0-1 year completely vaccinated
a Total children vaccinated less than five yeras multiplied by 33%.
b Total children vaccinated less than five years multiplied by 11%.
c Total children vaccinated less than five years multiplied by 9.4%.