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SCHOOL OF BUILDING & ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT – I – COST BENEFIT ANALYSIS FOR BUILDING & INFRASTRUCTURE PROJECTS-SARA5401

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Introduction

Any project can be viewed as a perturbation of the economy from what it would have been had some other project been undertaken instead. To determine whether the project should be undertaken, we first need to look at the levels of consumption of all commodities by all the individuals at all dates under the two different situations. If all individuals are better off with the project than without it, then clearly it should be adopted (if we adopt an individualistic social welfare function). If all the individuals are worse off, then clearly it should not be adopted. If some individuals are better off and others are worse off, whether we should adopt it or not depends critically on how we weight the gains and losses of different individuals. Although this is obviously the 'correct' procedure to follow in evaluating projects, it is not a practical one; the problem of benefit–cost analysis is simply whether we can find reasonable shortcuts.

THE RATIONALE OF COST–BENEFIT ANALYSIS

Cost–benefit analysis is not about money. It is not about inputs or outputs either. It is about welfare. Money is central to financial analysis but only instrumental in the economic appraisal of projects and policies. Money is the common unit in which economists express the social costs and benefits of projects. Volume of drinking water, accidents avoided, time savings and energy and labour consumed are measured in different units and we need a common unit of measure to express all these heterogeneous items in a homogeneous flow. This is the key role of money in cost–benefit analysis.

The creation of jobs is frequently presented as a benefit of a project, but labour is an input not an output. A motorway is not constructed to create jobs but to move people and goods. Workers building and maintaining a motorway represent a social cost equal to the net value lost in the next best use of this input. It is true that if a worker is unemployed, society does not lose as much as in the case of a similar worker already employed, but this only shows that cost values are context dependent.

The output of a project is easier to measure than its welfare effects. Public agencies report their activities with indicators such as passengers, water, electricity or the number of students taught within a training programme, but cost–benefit analysis sees output as a means to increase welfare. The success of a new facility cannot be explained by the number of users. It is possible to subsidize prices to induce people to use the new facility without increasing social welfare. Therefore, cost–benefit analysis is interested in the social value achieved from the outputs of the project to compare with the value of other goods sacrificed elsewhere for the sake of the project.

Cost–benefit analysis is about the well- being of individuals affected by the project and not about the number of trips or visits. The change in welfare is what economists want to measure, and this is quite a challenging task because welfare cannot be directly measured. To solve this problem, economists have found an alternative: to use money as an expression of welfare. I do not know how great the utility1 of a particular individual is when driving his car from *A* to *B* at a particular date and time, but if I am able to determine the amount of money to charge for this trip that makes him indifferent between driving or not, then interesting things can be said.
Cost–benefit analysis is not about money but money helps.

Cost–benefit analysis conceived as a toolkit for the selection of projects and policies, in the general interest of the society, presupposes the existence of a social planner, a benevolent government that compares benefits and costs before the implementation of projects and policies. Many economists and non- economists would consider such a view as naive, to say the least. An alternative view2 explains a government's action by the political power of different interest groups. Subsidies to agriculture, for example, could be better explained by the pressure of farmers than by an independent assessment of the social benefits and costs of agricultural policy.

Do we need to believe in the goodwill of the government to practice cost–benefit analysis? The answer is no. If we believe that a government's acts are better explained by the influence of interest groups, cost–benefit analysis can show who benefits and who loses as a result of particular projects, and the magnitudes of the gains and losses. This assessment can be very helpful in explaining which policies are adopted or even in influencing a government's decision. 'Cost–benefit analysis may be in the battle against misleading information spread by self-interested political pressure groups. Still, these analysts can influence political outcomes by making enough voters aware of the true effects of different policies'

To present the conceptual foundations and methods of cost–benefit analysis we will proceed 'as if' the government would aim for the best projects in the general interest of the society. Although we know of many cases that show that such an assumption is unrealistic, the simplification is harmless. As we proceed to identify benefits and costs, winners and losers and try to measure and value the main effects of the project under evaluation, the analysis is not going to change whatever our particular beliefs on the government's behavior.
We have started assuming the existence of a benevolent government.
This is not the only assumption and simplification in this book; in fact, there is no way to deal with the analysis of the economy but through the use of simplifying assumptions, replacing the actual world with a model that reflects the essence of the more complex reality that we want to understand.
To move forward, we need to clarify what is understood by acting in the general interest of the society. Let us consider that our benevolent government is evaluating the construction of a dam and a hydroelectric power station. The government doubts whether it should accept the project. By undertaking the project, the region would obtain electricity at a lower cost than without the project, recreation benefits, both in the stock of water (e.g. fishing and boating) and on the flow of reservoir release (e.g. rafting), and some jobs would be created at the time of its construction and during the lifetime of the project. Furthermore, there might be a multiplier effect, as the project would create new economic activity induced by the expenditure associated with the construction and operation of the project.
Economists point out that from the benefits described above we have to deduct some costs. First, the construction and maintenance costs, equal to the net benefits of alternative needs that have not been attended to because the public money has been assigned to the dam and power station, have to be deducted. They also argue that labour is an input, not an output, so it is a cost of the project, though its magnitude will depend on what is lost when the worker is employed within the project. The multiplier effect, if it exists, turns out to be irrelevant if it is also associated with the alternatives.
Second, all the other costs associated with the relocation of the inhabitants of the village in the area where the dam would be built and with the people negatively affected by the alteration of

the flow and course of the river should be deducted. The magnitude of these costs could be substantial.

The government considers all the relevant benefits and costs regardless, in principle, of who the beneficiaries and the losers are (assume for simplicity that all the effects are inside the country) and the government decides to undertake the project if, given the available information, the society improves. Its decision is not based on the arguments of the private companies that will build the dam and power station, nor on the campaign of the opponents. The decision takes into account the whole society, with social welfare as the unique reference. The challenge for our benevolent government is how to value all the benefits and costs and how to compare them given that beneficiaries and losers are individuals with

different income, education, health, and so on, and are affected at different moments during the lifespan of the project.

This water project, as any other public infrastructure such as parks, high speed rail, highways, ports or the introduction of policies such as environmental regulations, can be interpreted as perturbations in the economy affecting the welfare of different individuals at different moments in time compared with the situation without the project or policy, which does not necessarily mean the status quo but what would have happened in the absence of the project or policy.

The assessment of the effects of the project requires a benchmark. It is necessary to compare the world *with* and *without* the project: to recreate an alternative world, or the so- called counterfactual. Cost–benefit analysis practitioners have to solve two main problems. First, they have to build the counterfactual and this means to replicate the world without the project, a dynamic world that evolves without the perturbation introduced by the project. This is not an easy task because the time period for this exercise may be quite long, 40 years or more, and the values of key variables will possibly change in each one of these years, only some of them in predictable ways. Second, the practitioner has to imagine the world with the project, forecasting the main changes with respect to the counterfactual that he has previously created.

The expected changes when the project is implemented are then the result of the comparison with the counterfactual: the worse the counterfactual, the better the project. Hence, it is important to present all the assumptions and the data used to complete this exercise. Transparency and ex post evaluation can help to avoid both innocent errors and strategic misrepresentation.

Suppose the counterfactual and the world with the project have been properly designed and the expected changes have been estimated: time savings, enhanced water quality or a reduction in the number of fatal accidents.

Now, the analyst has to convert these values into monetary units ($)4 assuming that this is technically possible and morally acceptable. We want to measure changes in the welfare of the individuals who compose the society; however individuals' utility cannot be measured in the same way as the amount of electricity produced or the number of people displaced to build the dam. To decide on the goodness of the project we need to measure something that is unobservable. Furthermore what is observable – the production of electricity, number of individuals involved, extension of flooded surface, and so on – is not very useful if we do not translate the physical units into a common measure related to changes in individual utility, which allows the comparison between what is gained and what is lost.

Table 1.1 Benefits and costs of a hydroelectric power station (values in $)

Individual	Benefits	Costs	Net benefits
A	7	0	7
B	2	8	−6
C	3	4	−1
D	9	1	8
E	1	6	−5

Hence, though the ideal way of measuring the impact of our project is through utility functions (we would measure the change in utility of each individual) the problem is that these utility functions and the associated utility changes are unobservable. Converting the unobservable utility changes through an 'exchange rate' between utility and income to observable monetary units gives us a way of calculating the impact of the project.

One alternative solution might be to submit the project to a referendum and to accept the outcome: that is, accepting the view of the majority. Let us have a look at this in more detail. Table 1.1 collects the information (expressed in monetary units) of the benefits and costs of those affected by the construction of the dam and the hydroelectric power station. Our society consists of five individuals.

The individual *B*, for example, benefits from cheaper energy (+$2) but he also fishes downstream and the dam prevents him from practicing his favorite sport in the initial conditions (–$8). The result is a net loss of $6 for individual *B*. We could interpret the values in the column 'net benefits' as the monetary compensation that will be needed with the project to leave each individual indifferent without the project: for example, the individual

B would be willing to accept $6 and the individual *A* would be willing to pay $7.

The column 'net benefits' allows us to anticipate that the project would be rejected in a referendum. Individuals *A* and *D* would vote in favour, but individuals *B*, *C* and *E* would vote against it. Would it be a good decision to reject the construction of the water project? To answer this question we have to check whether the construction of the dam is a social improvement and for this purpose we need to define a decision criterion.

A possible criterion is the strong Pareto improvement. To move from one situation to another is a social improvement (in the sense of Pareto) if at least one person is better off without making anyone else worse off.

There are winners and nobody loses. We have seen that the referendum would result in the rejection of the project. Would it be possible, in these circumstances, to reach a Pareto improvement despite the outcome of the ballot?

Although it seems clear that the project under discussion would not be approved in a referendum, the society may gain from the project if, as it happens to be in this case, the benefits ($22) outweigh the costs ($19).

Suppose the project is carried out and part of the benefits is used to compensate individuals *B*, *C* and *E*, so that their net benefit is zero, leaving them indifferent. Table 1.1 shows that, after

compensation, there is a net benefit of $3 to share out as deemed appropriate. If the project is rejected this net gain would be lost.

What Is a Cost-Benefit Analysis (CBA)?

A cost-benefit analysis is a systematic process that businesses use to analyze which decisions to make and which to forgo. The cost-benefit analyst sums the potential rewards expected from a situation or action and then subtracts the total costs associated with taking that action. Some consultants or analysts also build models to assign a dollar value on intangible items, such as the benefits and costs associated with living in a certain town.

KEY TAKEAWAYS

- A cost-benefit analysis (CBA) is the process used to measure the benefits of a decision or taking action minus the costs associated with taking that action.
- A CBA involves measurable financial metrics such as revenue earned or costs saved as a result of the decision to pursue a project.
- A CBA can also include intangible benefits and costs or effects from a decision such as employees morale and customer satisfaction.

Understanding Cost-Benefit Analysis (CBA)

Before building a new plant or taking on a new project, prudent managers conduct a cost-benefit analysis to evaluate all the potential costs and revenues that a company might generate from the project. The outcome of the analysis will determine whether the project is financially feasible or if the company should pursue another project.

In many models, a cost-benefit analysis will also factor the opportunity cost into the decision-making process. Opportunity costs are alternative benefits that could have been realized when choosing one alternative over another. In other words, the opportunity cost is the forgone or missed opportunity as a result of a choice or decision. Factoring in opportunity costs allows project managers to weigh the benefits from alternative courses of action and not merely the current path or choice being considered in the cost-benefit analysis.

By considering all options and the potential missed opportunities, the cost-benefit analysis is more thorough and allows for better decision-making.

What Is Opportunity Cost?

Opportunity costs represent the potential benefits an individual, investor, or business misses out on when choosing one alternative over another. Because opportunity costs are, by definition, unseen, they can be easily overlooked. Understanding the potential missed opportunities when a business or individual chooses one investment over another allows for better decision-making.

KEY TAKEAWAYS

- Opportunity cost is the forgone benefit that would have been derived from an option not chosen.
- To properly evaluate opportunity costs, the costs and benefits of every option available must be considered and weighed against the others.
- Considering the value of opportunity costs can guide individuals and organizations to more profitable decision-making.

Formula and Calculation of Opportunity Cost

Formula and Calculation of Opportunity Cost

$$\text{Opportunity Cost} = \text{FO} - \text{CO}$$

where:

$\text{FO} = \text{Return on best forgone option}$

$\text{CO} = \text{Return on chosen option}$

The formula for calculating an opportunity cost is simply the difference between the expected returns of each option. Say that you have option A—to invest in the stock market hoping to generate capital gain returns. Meanwhile, Option B is to reinvest your money back into the business, expecting that newer equipment will increase production efficiency, leading to lower operational expenses and a higher profit margin.

Assume the expected return on investment in the stock market is 12% over the next year, and your company expects the equipment update to generate a 10% return over the same period. The opportunity cost of choosing the equipment over the stock market is (12% - 10%), which equals two percentage points. In other words, by investing in the business, you would forgo the opportunity to earn a higher return.

The Cost-Benefit Analysis Process

A cost-benefit analysis should begin with compiling a comprehensive list of all the costs and benefits associated with the project or decision.

The costs involved in a CBA might include the following:

- Direct costs would be direct labor involved in manufacturing, inventory, raw materials, manufacturing expenses.
- Indirect costs might include electricity, overhead costs from management, rent, and utilities.

- Intangible costs of a decision, such as the impact on customers, employees, or delivery times.
- Opportunity costs such as alternative investments, or buying a plant versus building one.
- Cost of potential risks such as regulatory risks, competition, and environmental impacts.

Benefits might include the following:

- Higher revenue and sales from increased production or new product.
- Intangible benefits, such as improved employee safety and morale, as well as customer satisfaction due to enhanced product offerings or faster delivery.
- Competitive advantage or market share gained as a result of the decision.

An analyst or project manager should apply a monetary measurement to all of the items on the cost-benefit list, taking special care not to underestimate costs or overestimate benefits. A conservative approach with a conscious effort to avoid any subjective tendencies when calculating estimates is best suited when assigning a value to both costs and benefits for a cost-benefit analysis.

Finally, the results of the aggregate costs and benefits should be compared quantitatively to determine if the benefits outweigh the costs. If so, then the rational decision is to go forward with the project. If not, the business should review the project to see if it can make adjustments to either increase benefits or decrease costs to make the project viable. Otherwise, the company should likely avoid the project.

Limitations of the Cost-Benefit Analysis

For projects that involve small- to mid-level capital expenditures and are short to intermediate in terms of time to completion, an in-depth cost-benefit analysis may be sufficient enough to make a well-informed, rational decision. For very large projects with a long-term time horizon, a cost-benefit analysis might fail to account for important financial concerns such as inflation, interest rates, varying cash flows, and the present value of money.

Alternative capital budgeting analysis methods, including net present value (NPV), could be more appropriate for these situations. The concept of present value states that an amount of money or cash in the present day is worth more than receiving the amount in the future since today's money could be invested and earn income.

One of the benefits of using the net present value for deciding on a project is that it uses an alternative rate of return that could be earned if the project had never been done. That return is discounted from the results. In other words, the project needs to earn at least more than the rate of return that could be earned elsewhere or the discount rate.

However, with any type of model used in performing a cost-benefit analysis, there are a significant amount of forecasts built into the models. The forecasts used in any CBA might include future revenue or sales, alternative rates of return, expected costs, and expected future

cash flows. If one or two of the forecasts are off, the CBA results would likely be thrown into question, thus highlighting the limitations in performing a cost-benefit analysis.

How does one Weigh Costs vs. Benefits?

Cost-benefit analysis (CBA) is a systematic method for quantifying and then comparing the total costs to the total expected rewards of undertaking a project or making an investment. If the benefits greatly outweigh the costs, the decision should go ahead; otherwise, it should probably not. CBAs, importantly, will also include the opportunity costs of missed or skipped projects.

What Is a Benefit-Cost Ratio (BRC)?

A benefit-cost ratio (BCR) is a ratio used in a cost-benefit analysis to summarize the overall relationship between the relative costs and benefits of a proposed project. BCR can be expressed in monetary or qualitative terms. If a project has a BCR greater than 1.0, the project is expected to deliver a positive net present value to a firm and its investors.

The benefit-cost ratio compares the present values of all benefits with the present value of all costs expected in a project or investment. A value greater than 1 indicates a profitable project with a total return exceeding the discount rate. A value of less than 1 suggests that the forecasted series of cash flows is not a profitable option.

What Are Some Tools or Methods Used in CBA?

Depending on the specific investment or project being evaluated, one may need to discount the time value of cash flows using net present value calculations. A benefit-cost ratio (BCR) may also be computed to summarize the overall relationship between the relative costs and benefits of a proposed project. Other tools may include regression modeling, valuation, and forecasting techniques.

What Are the Costs and Benefits of Doing a Cost-Benefit Analysis?

The process of doing a CBA itself has its own inherent costs and benefits. The costs involve the time needed to carefully understand and estimate all of the potential rewards and costs. This may also involve money paid to an analyst or consultant to carry out the work. One other potential downside is that various estimates and forecasts are required to build the CBA, and these assumptions may prove to be wrong or even biased.

What is a social economic perspective?

Socio-economics is characterized as an interdisciplinary perspective that can fill a major gap in social science and provide knowledge needed for wise policy making.

What are social and economic factors?

Social and economic factors are **drivers of the conditions in which people live, learn, work, and play**. Factors, such as employment, community safety, income, housing, transportation, educational attainment, social support, and discrimination account for roughly 40% of all health.

What Is Social Economics?

Social economics is a branch of economics—and a social science—that focuses on the relationship between social behavior and economics. Social economics consists of two broad perspectives that, though opposite in their approach, can be thought of as complementary. The first, pioneered by Nobelist Gary Becker, applies the basic theoretical and applied tools of neoclassical microeconomics to areas of human behavior not traditionally considered as part of economics proper, such as crime and punishment, drug abuse, marriage, and family decisions.

The second, applies the ideas of other social sciences, such as sociology, psychology, and identity group studies to subjects of an economic nature like consumer behavior or labor markets. These practitioners of social economics use history, current events, politics, and other social sciences to predict social trends that could potentially impact the economy. This strand of social economics is the primary focus of this article.

At times, the theories of social economics diverge from conventional economic theories. The theories of social economics often consider factors that are outside the focus of mainstream economics, including the effect of the environment and ecology on consumption and wealth.

KEY TAKEAWAYS

- Social economics is a branch of economics—and a social science—that focuses on the relationship between social behavior and economics.
- The theories of social economics often consider factors that are outside the focus of mainstream economics, including the effect of the environment and ecology on consumption and wealth.
- Social economics may attempt to explain how a particular social group or socioeconomic class behaves within a society, including their actions as consumers.
- Social economics is also referred to as socioeconomics.

Understanding Social Economics

- Social economics is primarily concerned with the interplay between social processes and economic activity within a society. Social economics may attempt to explain how a particular social group or socioeconomic class behaves within a society, including their actions as consumers.
- Different socioeconomic classes may have different priorities regarding how they direct their funds. A socioeconomic class is a group of people with similar characteristics. These characteristics can include social and economic standing, level of education, current profession, and ethnic background or heritage.

- Certain goods or services may be unavailable to specific socioeconomic classes based on their ability to afford them (as a result of their income). These goods or services can include access to more advanced or complete medical care, educational opportunities, and the ability to buy food that meets specific nutritional guidelines.

Gauging the Impact

An individual's socioeconomic status can significantly impact their educational attainment and financial security. For example, an individual from an affluent social class will likely have a greater opportunity to achieve higher education and may be expected to pursue such a goal by peers and other members of their class.

Completing higher education is more likely to increase their income potential, as well as provide opportunities to interact with people of similar or more advanced social standing and build beneficial social networks.

In contrast, higher education may not be attainable for an individual existing at or below the poverty level. Many studies have revealed that young children from families existing at or below the poverty level develop academic skills slower than children from affluent social classes. A lower socioeconomic status is also related to poor cognitive development, language, memory, socioemotional processing, and consequently poor income and health in adulthood.

What's more, school systems in communities that are primarily populated by those at or below the poverty-level are often underresourced, which negatively impacts students' academic progress and outcomes. Poor academic skills and progress, combined with high dropout rates, can impact children's academic achievement in the long-term (and further perpetuate the low socioeconomic status of the community).

Example of Social Economics

Children from low-income families generally do not have the same opportunities available to them as children from middle- or high-income families.

For example, low-income families may not be able to pay for their children's participation in team sports, music lessons, or private tutoring, which can propel them toward achieving a prosperous future (as well as provide them with growing confidence to take on more challenges). Also, these children may attend overcrowded schools where education is underfunded or understaffed.

What Is Welfare Economics?

Welfare economics is the study of how the allocation of resources and goods affects social welfare. This relates directly to the study of economic efficiency and income distribution, as well as how these two factors affect the overall well-being of people in the economy. In practical terms, welfare economists seek to provide tools to guide public policy to achieve beneficial social and economic outcomes for all of society. However, welfare economics is a

subjective study that depends heavily on chosen assumptions regarding how welfare can be defined, measured, and compared for individuals and society as a whole.

KEY TAKEAWAYS

- Welfare economics is the study of how the structure of markets and the allocation of economic goods and resources determines the overall well-being of society.
- Welfare economics seeks to evaluate the costs and benefits of changes to the economy and guide public policy toward increasing the total good of society, using tools such as cost-benefit analysis and social welfare functions.
- Welfare economics depends heavily on assumptions regarding the measurability and comparability of human welfare across individuals, and the value of other ethical and philosophical ideas about well-being.

Understanding Welfare Economics

Welfare economics begins with the application of utility theory in microeconomics. Utility refers to the perceived value associated with a particular good or service. In mainstream microeconomic theory, individuals seek to maximize their utility through their actions and consumption choices, and the interactions of buyers and sellers through the laws of supply and demand in competitive markets yield consumer and producer surplus.

Microeconomic comparison of consumer and producer surplus in markets under different market structures and conditions constitutes a basic version of welfare economics. The simplest version of welfare economics can be thought of as asking, "Which market structures and arrangements of economic resources across individuals and productive processes will maximize the sum total utility received by all individuals or will maximize the total of consumer and producer surplus across all markets?" Welfare economics seeks the economic state that will create the highest overall level of social satisfaction among its members.

Using CBA for Decision-Making

The connection between net benefits and Pareto efficiency should now be clear. *As long as analysts value all outcomes in terms of willingness to pay (or willingness to accept) and value all required inputs in terms of opportunity costs, then the sign of the net benefits indicates whether it would be possible to compensate those who bear costs sufficiently so that no one is made worse off and at least one person is better off.* Positive net benefits indicate the potential for compensation to make the policy Pareto-efficient; negative net benefits indicate the absence of this potential.

One could imagine the following decision rule for CBA: adopt only policies that are actually Pareto-efficient. In other words, only policies that yields positive benefits after providing full compensation to all those who bear costs would be adopted so that there would be at least some winners and no losers. Although conceptually this is appealing, such a rule would be extremely difficult to apply in practice for a number of reasons. First, it would place great informational burdens on analysts not just to measure aggregate costs and benefits, which can often be inferred

from observing prices and quantities in markets, but also to measure costs and benefits for each person, a task that would generally render CBA too costly to use. Second, once the distribution of costs and benefits at the individual level were known, the administrative costs of actually making specific transfers for each government policy would almost certainly be high.
Third, it is difficult to operate a practical system of compensation payments that does not distort the investment and work behavior of households. Fourth, the requirement that everyone be fully compensated would create a strong incentive for people to find ways to overstate the costs and understate the benefits that they expect to receive from policies, complicating the already difficult task of inferring how much each person is willing to pay for the impacts produced by the policy. The "actual Pareto efficiency" principle in practice would thus result in society forgoing many policies that offer positive net benefits and the diversion of much effort toward the seeking of unjustified compensation.

Potential Pareto Efficiency

CBA utilizes an alternative decision rule with somewhat less conceptual appeal, but much greater feasibility, than the actual Pareto efficiency rule. It is based on what is known as the *Kaldor–Hicks criterion*: a policy should be adopted if and only if those who will gain could fully compensate those who will lose and still be better off. The Kaldor–Hicks criterion provides the basis for the *potential Pareto efficiency rule*, or, more commonly, the *net benefits criterion: adopt only policies that have positive net benefits.* As long as net benefits are positive, it is possible that losers could be compensated so that the policy potentially could be Pareto improving. In terms of Figure 2.1, any point on the potential
Pareto frontier would pass the potential Pareto efficiency rule, while only those points on the potential Pareto frontier that guarantee at least $25 to each person (the labeled interior segment of the potential Pareto frontier) pass the actual Pareto efficiency rule.
In practice, the assessment of whether a particular policy would increase efficiency depends on whether it offers a *potential Pareto improvement.* That is, does the policy provide sufficient net gains so that all losers *could* be compensated? Potential Pareto efficiency is achieved only when all potential Pareto improvements have been exhausted.
Several justifications, aside from feasibility, are commonly offered in defense of the potential Pareto efficiency rule. First, by always choosing policies with positive net benefits, society maximizes aggregate wealth. This indirectly helps those who are worse off because richer societies have greater capability for helping their poorest members and, if redistribution is a normal good (that is, other things being equal, people want more of it as their wealth increases), members of society have a greater willingness to help.4 Second, it is likely that different policies will have different sets of winners and losers. Thus, if the rule is consistently applied to government activity, then costs and benefits will tend to average out across people so that each person is likely to realize positive net benefits from the full collection of policies. Third, as we discuss later in this chapter, the rule stands in contrast to the incentives in representative political systems to give too much weight to costs and benefits that accrue to organized groups and too little weight\ to costs and benefits that accrue to unorganized interests. Its use in public discourse may thereby reduce the chances that Pareto-inefficient policies will be adopted. Fourth, if a more equal distribution of wealth or income is an important goal, then it is possible to address it

directly through transfers after a large number of efficiency-enhancing policies have been adopted. In other words, redistribution, at least in theory, can be done “wholesale” with a single redistribution program rather than “retail” in each particular program.

Social Cost Benefits Analysis in Project Management

What Is Social Cost-Benefit Analysis In Project Management?

The primary goal of all businesses is to get maximum return on investments. Thus, the promoters prefer to assess commercial viability. However, some ventures may not give appealing results for business profitability, so such programs are executed because they have social consequences. These are infrastructure works, including roadway, rail, bridges, and certain other construction works, irrigation, electricity initiatives, etc., that have a major role in socio-economic concerns instead of merely commercial prosperity. Therefore, such initiatives are assessed for the net socio-economic advantages and cost control that is nothing other than the national survey of potential socio-economic costs.

So, SCBA, often known as Social Cost-Benefit Analysis in project management, has become a tool for effective financial evaluation. It is an approach to assessing infrastructure investments from a social (or economic) perspective.

What is a social cost-benefit analysis?

It is a technique used for determining the value of money, specifically public investments, and it is becoming extremely popular. In addition, it helps in decision-making regarding the numerous parts of the organization and closely related project design programs.

Benefits of SCBA in Project Management

Social cost-benefit analysis in project management enables a complete comparison of several project options. This is not merely a financial concern. Even so, an SCBA recognizes non-financial consequences as well. For instance, consider the effects of increased accessibility on the environment, the economy, and other factors.

Social cost-benefit analysis helps governments to pursue innovative initiatives that benefit all, not just a selected few. Additionally, it aids in the entire development of an economy by assisting in decision-making that increases job, investment, savings, and consumption, increasing a country's economic activity.

Social cost advantages can be used for both investments. Thus, public investment is vital for a developing nation's economic progress.

1. Market Instability

A private corporation would evaluate a deal based on productivity and relevant market prices. However, the government must consider additional variables. Determining social costs in the event of market inefficiency and when market pricing cannot specify them. These hidden social costs are referred to as shadow prices.

2. Investments & Savings

A venture that results in increased savings is considered an investment in a market.

3. Income is distributed and redistributed

The initiative should not lead to revenue accumulation in the control of a few and the distribution of income.

4. Career and Living Standards

The impact of a program on employment and level of livelihood will also be considered. Therefore, the contract should result in a rise in employment and living standards.

5. Externalities

Externalities can be detrimental and advantageous to an enterprise. As a result, both impacts must be considered before approving a deal. For example, positive externalities can take the shape of technological advances, while negative externalities might take the form of rapid urbanization and ecological degradation.

6. Subsidy and Taxation

Taxation and subsidies are treated as expenses and revenue, respectively. However, taxation and subsidy are regarded as transfer payments for social cost-benefit analysis.

What is the scope of SCBA?

SCBA's purpose is to establish the financial benefits of each venture in perspective of shadow prices because initiatives impact people's savings and investments and the development's impact

on the revenue sharing in society. Additionally, it is critical to consider how certain factors like employment and self-sufficiency will be achieved if the strategy is delivered.

SCBA can be used to engage both in the public and private sectors.

1. Public investment: conducting social cost analysis for economic infrastructure development is critical for the developing world. When the national government contributes to shaping that country's economy, it is essential to analyze the development's social impact.

2. Private investment: Evaluating the social impact of private development initiatives is vital as federal and quasi-government authorities authorize these initiatives.

Different Approaches of SCBA in Project Management

By the late 1960s and early 1970s, two distinct approaches to SCBA had developed. These are as follows: 1. UNIDO's Approach 2. L-M Approach.

1. UNIDO's Approach

The UNIDO (United Nations Industrial Development Organization) planning methodology is as follows: The UNIDO method was reflected in the project assessment principles, establishing a systematic assessment for SCBA in developing economies. However, due to the severity and complexity of this task, concise and functional guidance for project evaluation in execution was required. Therefore, the fundamental principle of the method is the introduction in 1978 of the UNIDO Guidance to Practical Project Assessment.

The appraisal process is carried out on both planned and completed projects. It is a systematic method for determining the feasibility of a project or idea. It helps determine the feasibility before allocating funds to it. It frequently entails an evaluation of various scenarios, which is accomplished by applying any decision procedure or financial evaluation criteria.

The UNIDO project evaluation technique consists of five phases:

1. Assessment of the proposal's market performance at market values.
2. Determining the net benefit from a financial perspective.
3. Adaptation to account for the development's implications on savings and investment.
4. Adaptation to account for the program's impacts on wealth distribution.
5. Modifying the program's results on merit products with a social worth is not equivalent to their economic importance.

2. L-M (Little-Mirrlees) Approach

I.M.D. Little and J.A. Mirlees pioneered this technique in social cost-benefit analysis. The essential principle of this method is that in developing countries, the social cost of using a product varies significantly from the amount charged for it. As a result, Shadow Prices are required to signify the actual worth of a resource to the community. The LM Strategy covers all aspects of SCBA in developing nations.

L-M Numeraire is a source of uncommitted public revenue at the moment. A project's resources – inputs and outputs – are categorized primarily as labor traded goods and non-traded interests. As a result, to determine the actual value of such sources, we must choose –

Shadow Wage Rate (SWR)

The SWR is used to calculate the potential cost of adding a person to the assignment. This requires us to ascertain -

- The value of production is lost as a result of the usage of a unit of labor.
- The expense of extra consumption owing to labor transfer

Traded Goods Shadow Pricing

The shadow pricing of traded items is simply the cost at the international market.

- If a commodity is shipped, its FOB price serves as the shadow pricing;
- When goods are imported, their shadow price is equal to their CIF price.

Non-traded Goods' Shadow Pricing

Non-traded commodities are those that do not access international trade. (– for example, land, construction, and logistics). As a result, they have no noticeable border pricing.

UNIDO vs L-M Approach

UNIDO's approach is widespread in the country, whereas the L-M system incorporates international issues as well. The UNIDO methodology prioritizes efficiency, cost reductions, and redistribution at various levels. The L-M methodology, on the other hand, views these features in parallel.

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SCHOOL OF BUILDING & ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT – II – COST BENEFIT ANALYSIS FOR BUILDING & INFRASTRUCTURE PROJECTS-SARA5401

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Social cost-benefit analysis

Social cost-benefit analysis can be seen as a practical application of welfare economics. In welfare economics, welfare is a broad concept which includes all utility and disutility experienced from any change in the economy. As a consequence, SCBA includes all changes in utility caused by a (proposed) government policy. In economics, a Pareto improvement is defined as a change which increases the utility of at least one person without decreasing the utility of any person. As policies usually entail a lower utility for at least some people (e.g. subsidies are costs to tax payers), welfare economics uses a less forbidding test called the Hicks-Kaldor criterion. This criterion states that a policy increases welfare if those whose utility falls can - in theory - be financially compensated by those whose utility rises, and after this a Pareto improvement occurs. The application of this criterion requires that the money value of utility changes caused by policy impacts is known. In SCBA, these money values are estimated.

SCBA makes a distinction between direct and indirect economic effects of government policies on the one hand, and external effects on the other hand. Direct effects are effects in the market in which supply, demand or prices are influenced by the policy which is investigated. These effects are sometimes called effects in primary markets

SCBA makes a distinction between direct and indirect economic effects of government policies on the one hand, and external effects on the other hand. Direct effects are effects in the market in which supply, demand or prices are influenced by the policy which is investigated. These effects are sometimes called effects in primary markets or pecuniary external effects External effects or externalities are utility impacts which are not included in market transactions (more formally: impacts not included in the utility functions, production functions and costs of the actors involved in market transactions). We note that although externalities are not a part of market transactions, they will in all likelihood have an influence on market transactions in the end. For example, aircraft noise reduces the value of houses and greenhouse emissions may affect the price of agricultural land in the long term Externalities are sometimes called “technological external effects” to distinguish them from “pecuniary external effects” (indirect effects or wider economic effects). We use the terms externalities and external effects for “technological external effects”

An important distinction in SCBA is between ex ante and ex post studies. Ex ante (‘before’) SCBA is used to assess whether a policy proposal is viable when the decision has not been taken yet. Ex post (‘after’) SCBA is carried out after the policy has been implemented. Ex ante SCBA implies that the effects of a policy have to be estimated.

External effects

The concept of external effects forms an important part of welfare economics, and therefore also of SCBA. Moreover, the presence of external effects is the main rationale for social cost benefit analysis, as non-external effects are already considered in private choices. If no external effects occur, government intervention may be aimed at improving the distribution of welfare, but this implies that total welfare is reduced if there are no market imperfections. This

trade-off between efficiency and distribution is one of the core tenets of welfare economics. However, government policies may increase total welfare if externalities or other market imperfections are present.
One way of conducting SCBA is to estimate only the value of external effects, assuming that private costs and benefits more or less cancel each other out. This approach has the advantage of (relative) simplicity, but also implies two drawbacks. First, consumer and producer surpluses may change as a consequence of government policies. These are welfare effects which should be taken into account. Second, leaving out direct and indirect effects implies that the effects of the policy on the distribution of welfare are not known. As politicians, the media and the general public tend to focus on effects for specific groups, presenting a cost-benefit analysis without information on distributional effects runs the risk of making the analysis unimportant in public debate.
One of the main challenges in SCBA is to include external effects lacking 'hard evidence' in the calculation. The valuation of external effects is often relatively difficult compared to the valuation of other effects. These other effects occur within markets, and can often be observed in practice. For instance, the value of time savings are can be relatively accurately estimated on the basis of empirical studies and transport models. But the basis for valuation of environmental impacts is much weaker and not unequivocal to say the least. Krupp (1963) stated already 50 years ago that "Externalities … reflect conceptual difficulties at the boundaries of microeconomic theory." For example the social cost of curtailing CO2 emissions can be estimated on the basis of different methodologies, and even for a specific methodology the degree of uncertainty is large.

The methods used to estimate external effects in SCBA may be divided in methods based on revealed preferences in markets and behaviour and methods based on stated preference surveys A much-used revealed preference methods is hedonic prices, in which the impacts of external effects on market prices is estimated, e.g. the impact of the proximity of nature on the price of houses. Another revealed preference method is estimating the travel costs people pay to visit nature reserves, as a lower bound for the value they attach to these visits.

What Is Shadow Pricing?

The term shadow pricing is used to refer to either one of two things:

1. The actual market value of a money market fund share even if its stated value is $1 per share.
2. The assignment of a dollar value to an abstract commodity that is not ordinarily quantifiable as having a market price but needs to be assigned a valuation to conduct a cost-benefit analysis.

The latter instance is more common and involves a shadow price that is assigned to goods that are not generally bought and sold as separate assets in a marketplace, such as production costs or intangible assets.

KEY TAKEAWAYS

- A shadow price is an estimated price for something that is not normally priced or sold in the market.
- Shadow pricing can provide businesses with a better understanding of the costs and benefits associated with a project.
- However, shadow pricing is inexact as it relies on subjective assumptions and lacks reliable data to fall back on.
- It is often used in cost-benefit accounting to value intangible assets, but can also be used to reveal the true price of a money market share, or by economists to put a price tag on externalities.
- Shadow pricing is also frequently used by economists to determine the value of public infrastructure projects like public parks and transportation.

How Shadow Pricing Works

Shadow pricing as it relates to money market funds refers to the practice of accounting the price of securities based on amortized costs rather than on their assigned market value. Money market fund shares are always assigned a nominal net asset value (NAV) of $1, even though the actual NAV falls slightly above or below this figure.

Such funds are required by law to disclose the actual NAV—the shadow share price—to show the fund's performance to investors more accurately. However, the use of the term "shadow price" in relation to money market funds is the less common usage of the phrase. It is more frequently applied in the process of cost-benefit analysis in business decision-making..

In its most common usage, a shadow price is an "artificial" price assigned to a non-priced asset or accounting entry. Shadow pricing is frequently guided by certain assumptions about costs or value. It is generally a subjective and inexact, or imprecise, endeavor. To make a decision regarding the undertaking of a project or investment, businesses often perform a comparative analysis of the project or investment cost against the projected benefits.

In performing a cost-benefit analysis, a business must often account for the costs or benefits of intangible assets that are difficult to assign a dollar value to but that must nonetheless be monetarily quantified for the purpose of performing the analysis.

Advantages and Disadvantages of Shadow Pricing

Using shadow pricing helps a business obtain a fuller understanding of its project's real value. It is a necessary part of running a cost-benefit analysis and can assist management in their decisions about various aspects of a project's strategy and scope. Shadow pricing encourages responsible ethical behavior and is a vital tool in accurately evaluating a project.

That being said, there are a number of limitations to shadow pricing. Most notably, shadow pricing is inherently subjective; because the assets it attempts to value are intangible, the shadow price is proofless. Furthermore, because analysts must employ a fair amount of

guesswork, there is significant room for bias. This means there is also a good chance the shadow price is not accurate. If the methodology used to create the shadow price is flawed, the business may direct its actions in a way that won't benefit and could discredit the company.

Finally, some critics believe shadow pricing puts too much emphasis on short-term social opportunity cost while ignoring the long-term priorities of the business.

When Is Shadow Pricing Used?

Shadow pricing is an incredibly useful tool when evaluating a project. Even though shadow pricing only provides a rough estimate, it helps management assess the value of certain operations and attempts to place a monetary value on the different tasks associated with the project. Furthermore, when a company wants to run a cost-benefit analysis, it must use shadow pricing to assign values to intangible items.

Shadow pricing is also frequently used in public policy in order to designate the value of various public infrastructure projects such as public transportation, parks, and bike lanes. Economists seeking the societal value of projects like public parks will use shadow pricing to demonstrate the benefits of certain infrastructure projects that are not typically assigned a monetary value.

Example of Shadow Pricing

An example of shadow pricing as applied to a proposed business plan to renovate a company's office facilities might be the assignment of a dollar value to the expected benefits of doing the renovation. While the cost of the renovation can easily be assigned a dollar value, there are elements of the project's expected benefit that must be assigned a shadow price because they are not as easy to quantify.

The possible benefits of the project include the following:

- Improved employee morale
- Lower staff recruiting costs
- A lower employee turnover rate and increased productivity

Since it is impossible to assign a precise dollar value to such potential benefits, an estimated shadow price is assigned to set a dollar figure to compare with the cost figure.

Calculating the Net Benefits to the Referent Group

Introduction The referent group in a social benefit-cost analysis is unlikely to consist only of the equity holders of the private firm, at one extreme, or everyone affected by the project in the whole world, at the other extreme. The costs and benefits to the former group were analysed in Chapter 4, and those to the latter group in Chapter 5. In this Chapter we analyse the costs and benefits to the referent group. Our client will tell us what the referent group is, and she will normally nominate all groups affected by the project (sometimes referred to as “stakeholders”)

who are resident in her State or country, including effects on government receipts or payments: in the ICP Case Study discussed in the Appendices, "Thailand" is the referent group. As noted in Chapter 1 it is sometimes easier to specify who is not a member of the referent group than to identify all the relevant sub-groups; in the ICP Case Study, of those groups who benefit or incur costs, the foreign equity holders in the firm and the foreign financial institution which lends to the project are not members of the referent group. This means that the aggregate net benefits to the referent group can be calculated by subtracting the net cash flows experienced by these two groups from the efficiency net benefits of the project discussed in Chapter 5. Thus we can open Part 5 of our spreadsheet – the Referent Group Benefit-Cost Account – by entering the efficiency net benefits row less the equity holder's and foreign financial institution's net benefit rows. We have now completed the aggregate referent group (or "social") BCA. We also want a disaggregated analysis of the net benefits to the referent group for two reasons. The main reason is that our client will want information about the distribution of net benefits or costs among sub-groups because this will influence the project's attractiveness to the political decision-maker. The other reason is that if we enumerate all the sub-groups affected by the project, measure the net benefits to each, sum them and get the same answer as our aggregate measure, we can be fairly sure the analysis is correct, or, at least, is internally consistent. It is very common to omit some benefits or costs in the first run of the analysis and having a check of this kind is extremely useful.

How to Identify Referent Group Benefits in Practice

It is sometimes difficult to identify all the sub-groups within the referent group who are affected by the project, and it is not unusual for some group or category of net benefit to be omitted from the first draft of the Referent Group Benefit-Cost Account. Fortunately, as noted above, this kind of error can readily be detected within our project appraisal framework by the existence of a discrepancy between the measure of aggregate referent group net benefits computed by subtracting non-referent group benefits from the efficiency net benefits and the measure computed by aggregating the net benefits to various sub-groups within the referent group.

In principle there is a four-way classification of net benefits, illustrated by Table 6.1, distinguishing net benefits which accrue to the referent and non-referent groups respectively, and net benefits which either are, or are not properly measured by market prices.

Table 6.1 Classification of Net Benefits

	Net Benefits Accruing to:	
	Referent Group	**Non-Referent Group**
Net Benefits Measured by Market Prices	A	B
Net Benefits not Measured by Market Prices	C	D

Areas A, B and C correspond to the specific example illustrated by Figure 1.3 in Chapter 1. However, area D is a further potential category of net benefit which may be encountered in general. Figure 1.3 can be updated to include this additional category, and the revised diagram is presented here as Figure 6.1.

The difference between Figures 6.1 and 1.3 is that **Area D** has been added. This allows for a situation where there are net benefits (costs) to non-referent group members arising because of divergences between market prices and efficiency prices. For example, if a negative externality, pollution, arising from a project is borne by stakeholders outside the referent group, perhaps across a state or international boundary, the cost of this should be included in the efficiency benefit-cost analysis (now defined as area A+B+C+D), but subtracted along with area B from the efficiency cash flow to derive the aggregate referent group cash flow (area A+C).

Table 6.1 and Figure 6.1 can be used to consider the categories of referent group and non-referent group net benefits in the ICP Case Study discussed in the Appendix. In this example:

- **Area A** contains the net benefits to the domestic financial institution and the government, which constitute the balance of the net benefits to referent group members identified by the project analysis at market prices.
- **Area B** contains the returns to foreign equity holders and foreign lenders, which constitute that part of the project net benefits, as measured by market prices, which accrues to non referent group members.
- **Area C** contains referent group net benefits in the form of rents to the domestic insurance company, the electricity utility, and labour, which are external to the project. Since there are no non-market effects, such as increased pollution, referred to in the case study, this category is not included in the referent group analysis in this case. However, in general, non-marketed effects would be included in Area C or D of Figure 6.1.
- **Area D** is empty because, as noted above, in the case study there are no non-referent group net benefits not measured by market prices.

The scope for error in identifying referent group net benefits can be narrowed by following some simple guidelines as to where to expect to find referent group net benefits. There are two main ways of identifying referent group benefits: one way is to follow the tax and financing flows generated by the project, and the other is to examine the shadow-prices used in the analysis. Financial flows distribute the net benefits of a project among private sector stakeholders, and between the private and public sector. The public sector is normally part of the referent group, but some private sector agents, such as foreign firms, may be excluded.

Shadow-prices identify differences between private and efficiency valuations of inputs or outputs, and the differences may represent benefits or costs to members of the referent group.

Consider first changes in tax or subsidy flows as a result of the project. The project may result in changes in direct tax revenues, such as income or company tax, and changes in indirect tax revenues, such as tariffs and sales taxes. When these tax revenue changes are transfers among members of the referent group they net out of the aggregate referent group net benefit calculation: in Example 5.4 in the previous chapter, for example, the project resulted in a reduction in diesel fuel consumption which provided a gain to government in the form of reduced fuel subsidies paid, and a loss to farmers in the form of reduced fuel subsidies received.

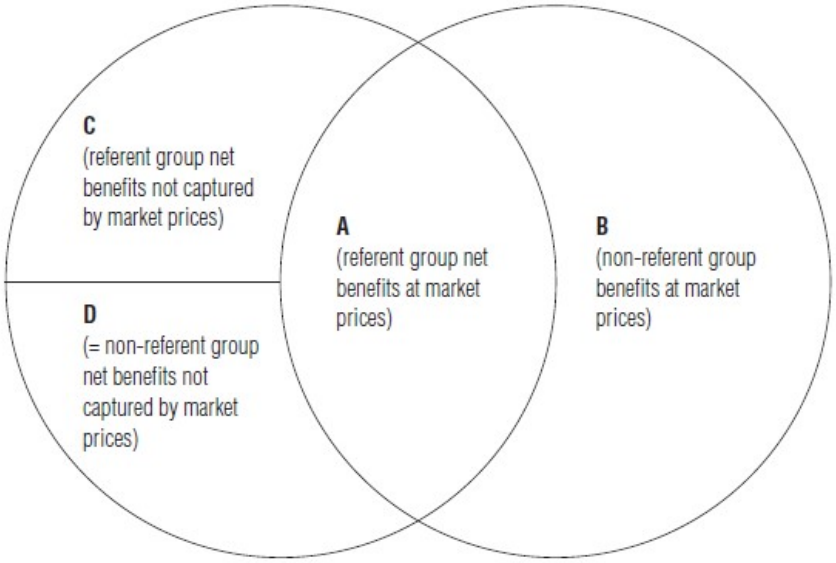


Figure 6.1 The Relationship between Referent Group and Non-referent Group Net Benefits at Market Prices and Efficiency Prices

When changes in tax flows involve transfers between the referent group and the rest of the world, on the other hand, the referent group experiences a net gain or loss, depending on the direction of the flow. The net benefit is recorded as a gain or loss to the domestic government.

Now consider the private financing flows associated with the project. These flows are not relevant to the efficiency benefit-cost analysis as they simply shift benefits and costs from one group to another. However they are relevant to the construction of the referent group benefit-cost account if they transfer net benefits between members and non-members of the referent group, or between members of the referent group, but are not relevant if they transfer net benefits among non-referent group members. An example of a financial flow which transfers net benefits between members and non-members of the referent group is provided by a domestic bank which lends money to a project to be undertaken by a foreign company. The bank advances a loan and then receives a series of interest payments and principal repayments. The initial loan is a cost to the domestic financial institutions section of the referent group benefit-cost account, while the interest and principal repayment flows are benefits. The present value of the net benefit to this sub-group will vary depending on the interest rate charged on the loan and the discount rate used in the social benefit-cost analysis.

Another clue to the existence of referent group net benefits lies in the rationale for shadow-pricing. Suppose that an input, such as labour, is assigned a shadow-price lower than its market price. This tells us that the wage exceeds the opportunity cost of labour, and, hence, that the labour employed on the project is receiving a net benefit. Since domestic labour is one of the sub-groups within the referent group, that net benefit should be recorded among the referent group net benefits. Now suppose that an input was assigned a shadow-price in excess of its market price. For example, labour to be diverted from a monopoly or monopsony to work on the project would be shadow-priced at the value of the marginal product of labour.

The fact that the shadow-price of the input exceeds the market price tells us that the project is imposing a loss somewhere in the economy and this loss will generally be experienced by a

member of the referent group. In the present example, there is a loss of profit to the domestic monopoly or monopsony which is part of the referent group.

We have considered cases where the shadow-pricing of inputs may help us identify categories of referent group net benefits. The same applies to the shadow-pricing of outputs. For example, suppose that a project produces an import-replacing good. Instead of valuing output at its market price, which is the border price plus the tariff, we shadow-price it at the border price. When a project output is shadow-priced at a lower price than the market price this generally indicates a loss to some members of the referent group. In the example of an import-replacing project, the loss is incurred by the government in the form of a reduction in tariff revenue. Now suppose that a project output is shadow-priced at a price above its market price. This will generally indicate a benefit to members of the referent group. An example is influenza vaccinations which may command a price in the market, but will have a social value in excess of the individual willingness to pay for them because, in addition to the benefit they confer on the buyer, they reduce the chance of others catching the disease. While it is difficult to place a dollar value on a non-marketed service of this nature, it is nevertheless clearly a referent group net benefit.

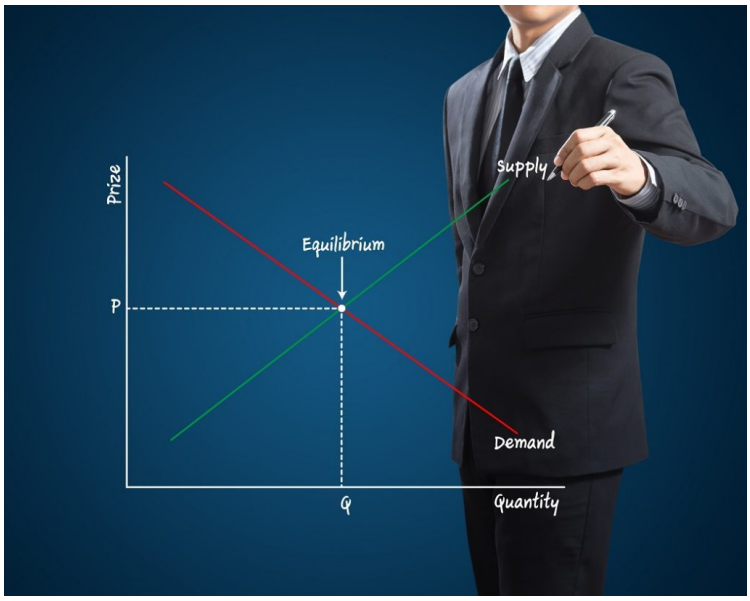
In summarizing the relationship between shadow-prices and referent group net benefits, we can conclude that where the market price of an input exceeds (is less than) its shadow price, there are likely to be referent group benefits (costs); and where the market price of an output exceeds (is less than) its shadow-price, there are likely to be referent group costs (benefits). Table 6.2 summarizes this simple rule and provides an example of each of the four cases.

Table 6.2 Using Shadow-prices to Identify Referent Group Benefits and Costs

	INPUT	OUTPUT
MARKET PRICE GREATER THAN SHADOW-PRICE	BENEFIT TO OWNER OF THE INPUT e.g. Otherwise unemployed labour	COST TO GOVERNMENT OR PUBLIC e.g. Loss of tariff revenue, cost of pollution generated by use
MARKET PRICE LESS THAN SHADOW-PRICE	COST TO PREVIOUS USER OF THE INPUT e.g. Monopoly or monopsony firm	BENEFIT TO PUBLIC e.g. Value of vaccination to those other than the vaccinated

What are Consumer Surplus and Producer Surplus?

Both consumer surplus and producer surplus are economic terms used to define market wellness by studying the relationship between the consumers and suppliers. They explain the opportunity cost consumers forego to gain a marginal benefit for buying a good or service. To the producer, it is the willingness and ability to produce an extra unit of a product based on the marginal cost of producing more goods.



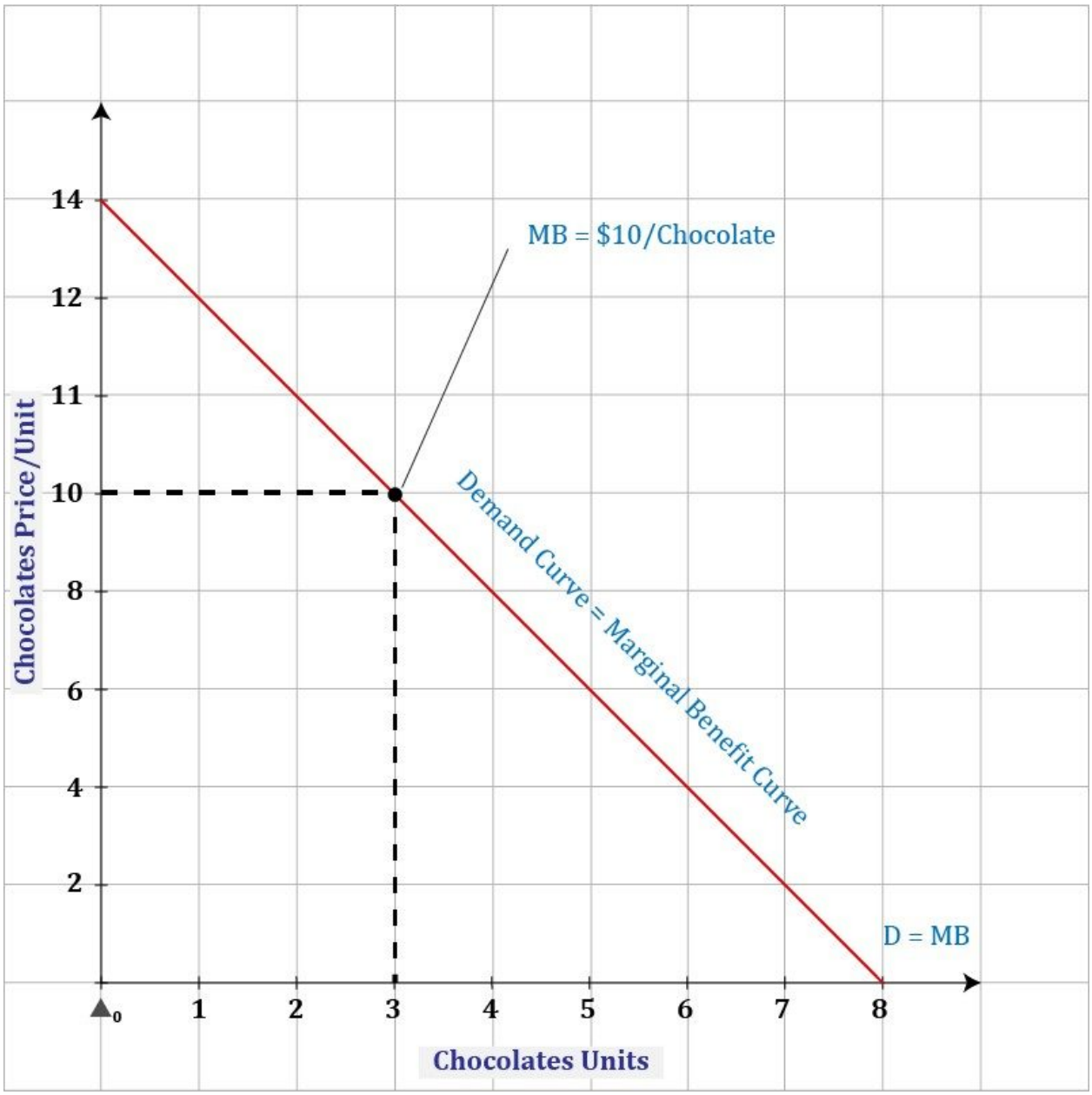
Summary

- Both consumer surplus and producer surplus are economic terms used to define market wellness by studying the relationship between the consumers and suppliers.
- The consumer surplus refers to the difference between what a consumer is willing to pay and what they paid for a product.
- The producer surplus is the difference between the market price and the lowest price a producer is willing to accept to produce a good.

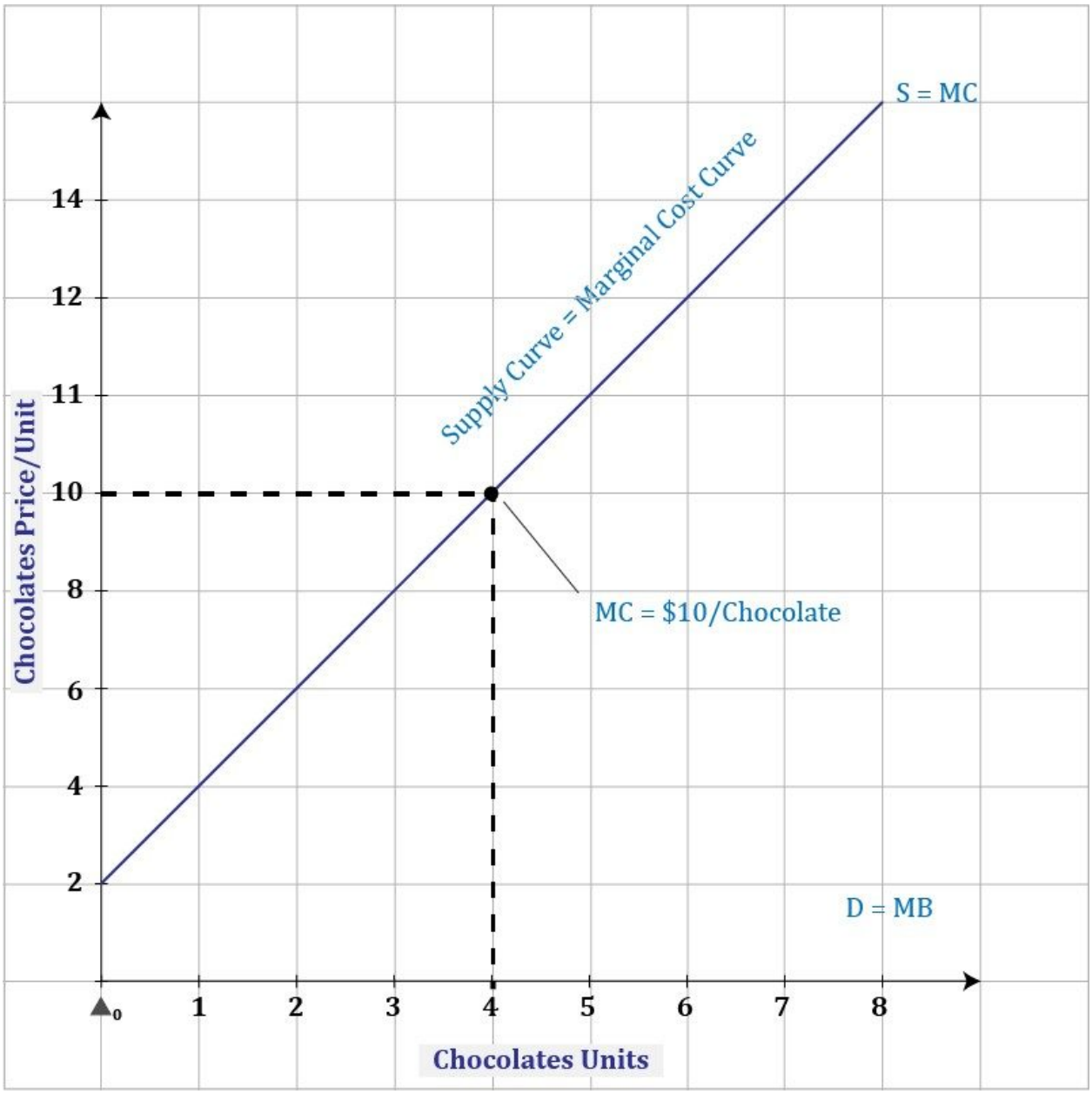
Understanding Consumer Surplus and Producer Surplus

When discussing consumer and producer surplus, it is important to understand some base concepts used by economists to explain the inter-relationship.

Both consumer and producer surplus can be graphed to display either a demand curve or marginal benefit curve (MB) and a supply curve or marginal cost curve (MC).



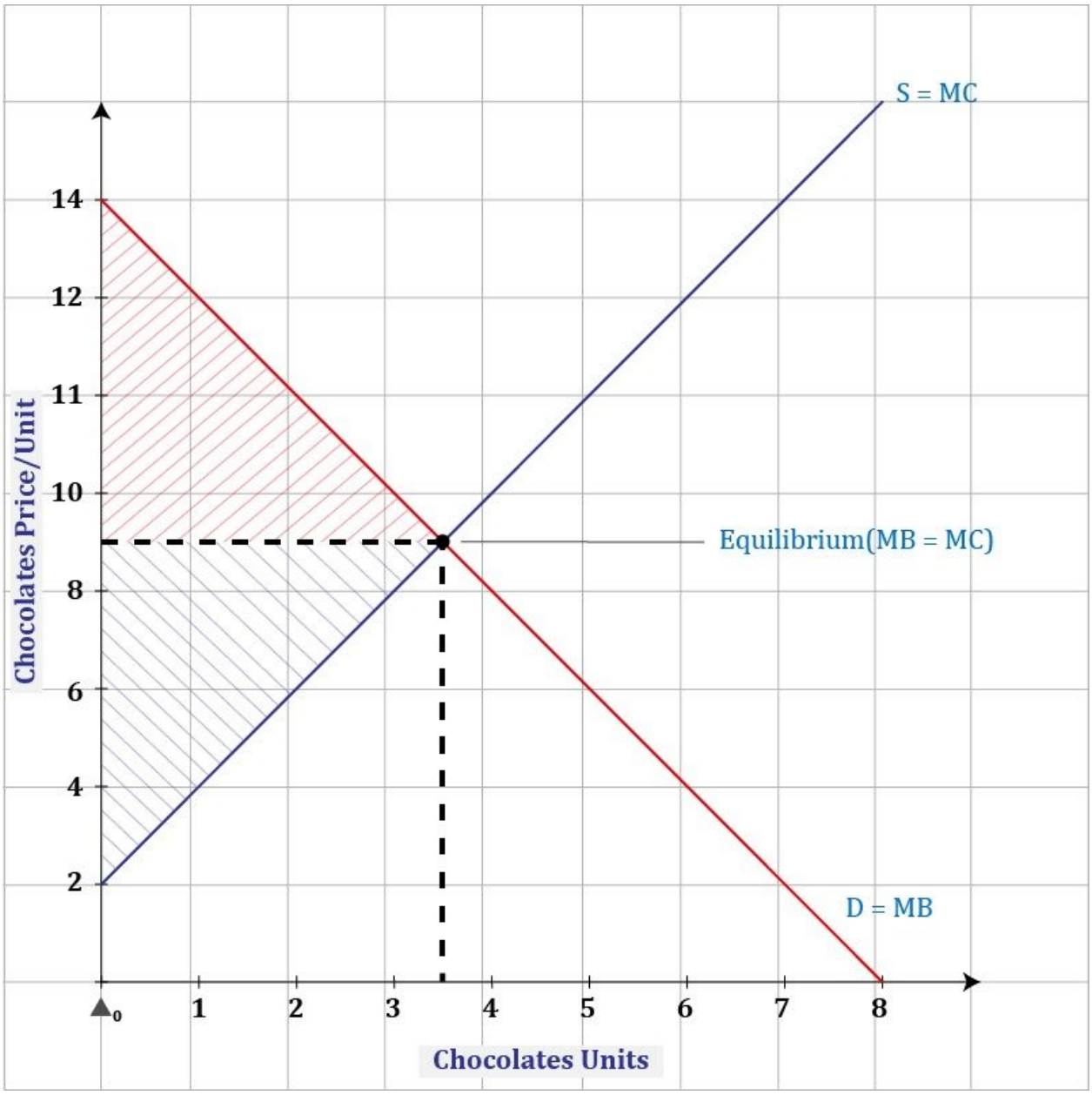
Consumer surplus refers to the monetary gain enjoyed when a purchaser buys a product for less than what they normally would be willing to pay. Each corresponding product unit price along the supply curve is known as the marginal cost (MC).



On the other hand, the producer surplus is the price difference between the lowest cost to supply the market versus the actual price consumers are willing to pay. The price of a product unit along the supply curve is known as the marginal cost (MC).

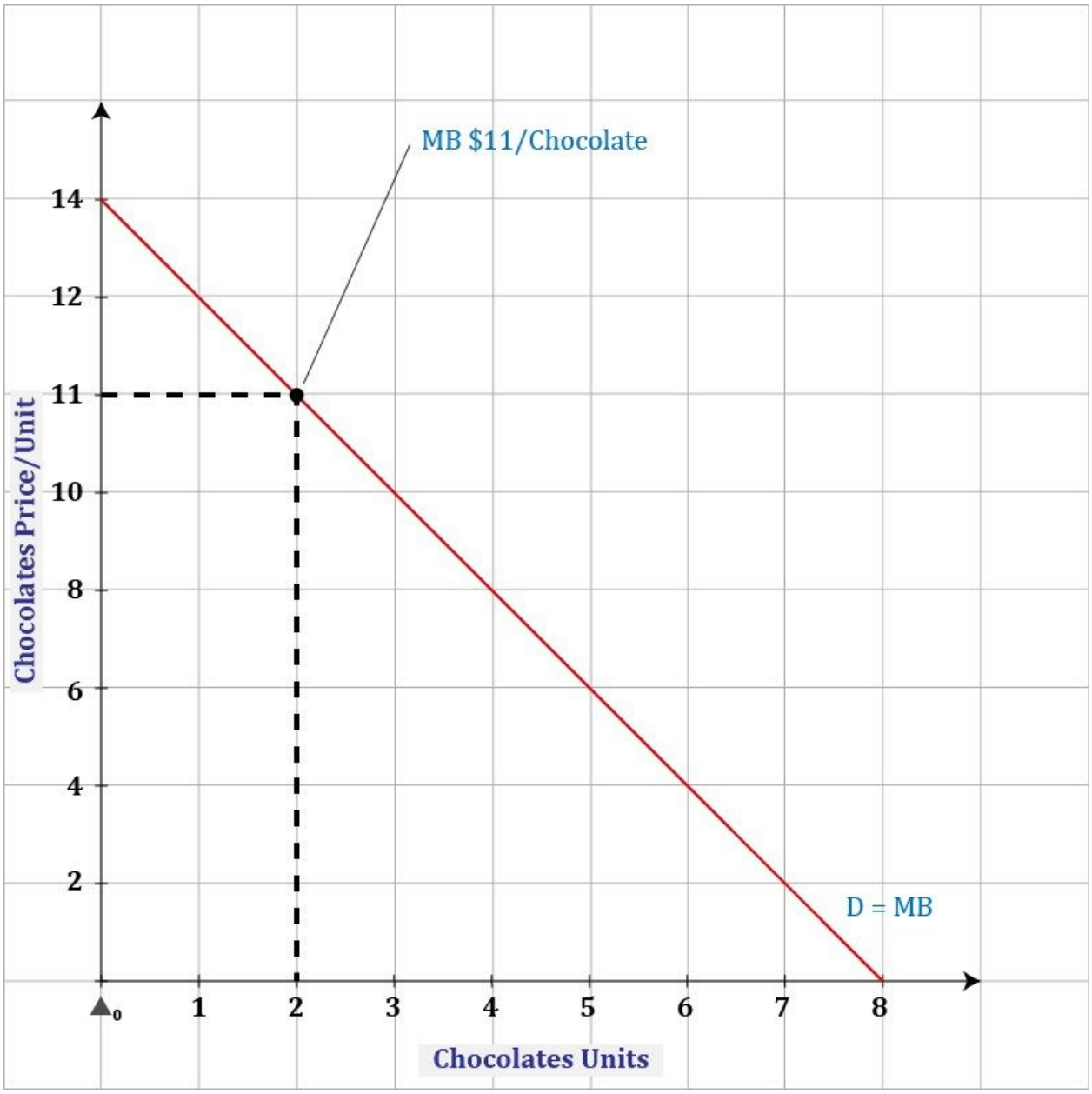
When graphing consumer surplus, the area above every extra unit of consumption, is referred to as the total consumer surplus. Similarly, the area above the supply curve for every extra unit brought to the market is referred to as the total producer surplus.

When you add both the consumer and producer surplus, you get the total surplus, also known as total welfare or community surplus. It is used to determine the well-being of the market. When all factors are constant, in a perfect market state, an equilibrium is achieved. This state is also referred to as allocative efficiency – the marginal cost and marginal benefit are equal.



Understanding Consumer Surplus

To fully conceptualize consumer surplus, take an example of a demand curve of chocolates plotted on a graph. The unit price is plotted on the Y-axis and the actual chocolate units of demand per day on the X units. The graph below shows the consumer surplus when consumers purchase two units of chocolates.



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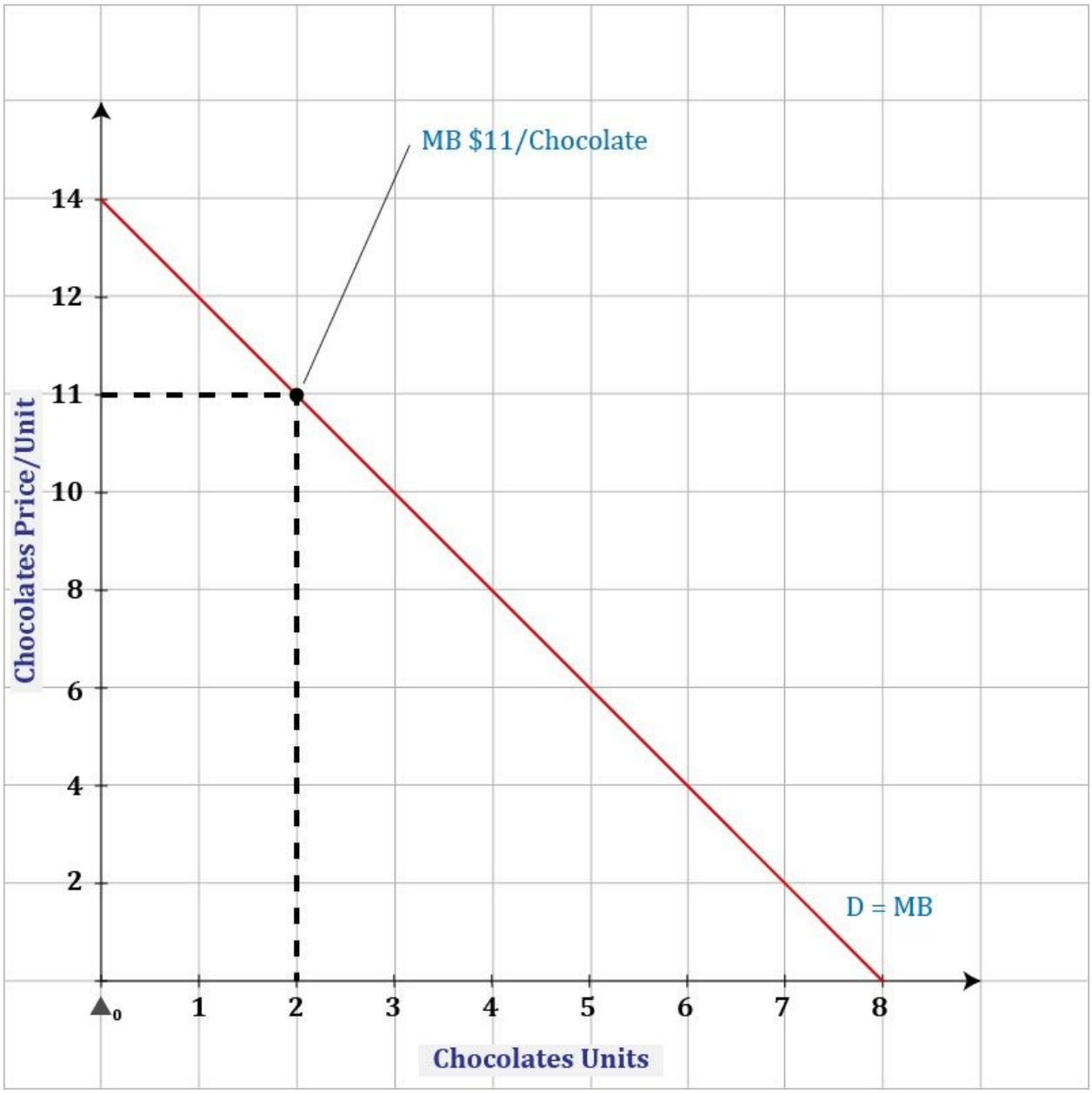
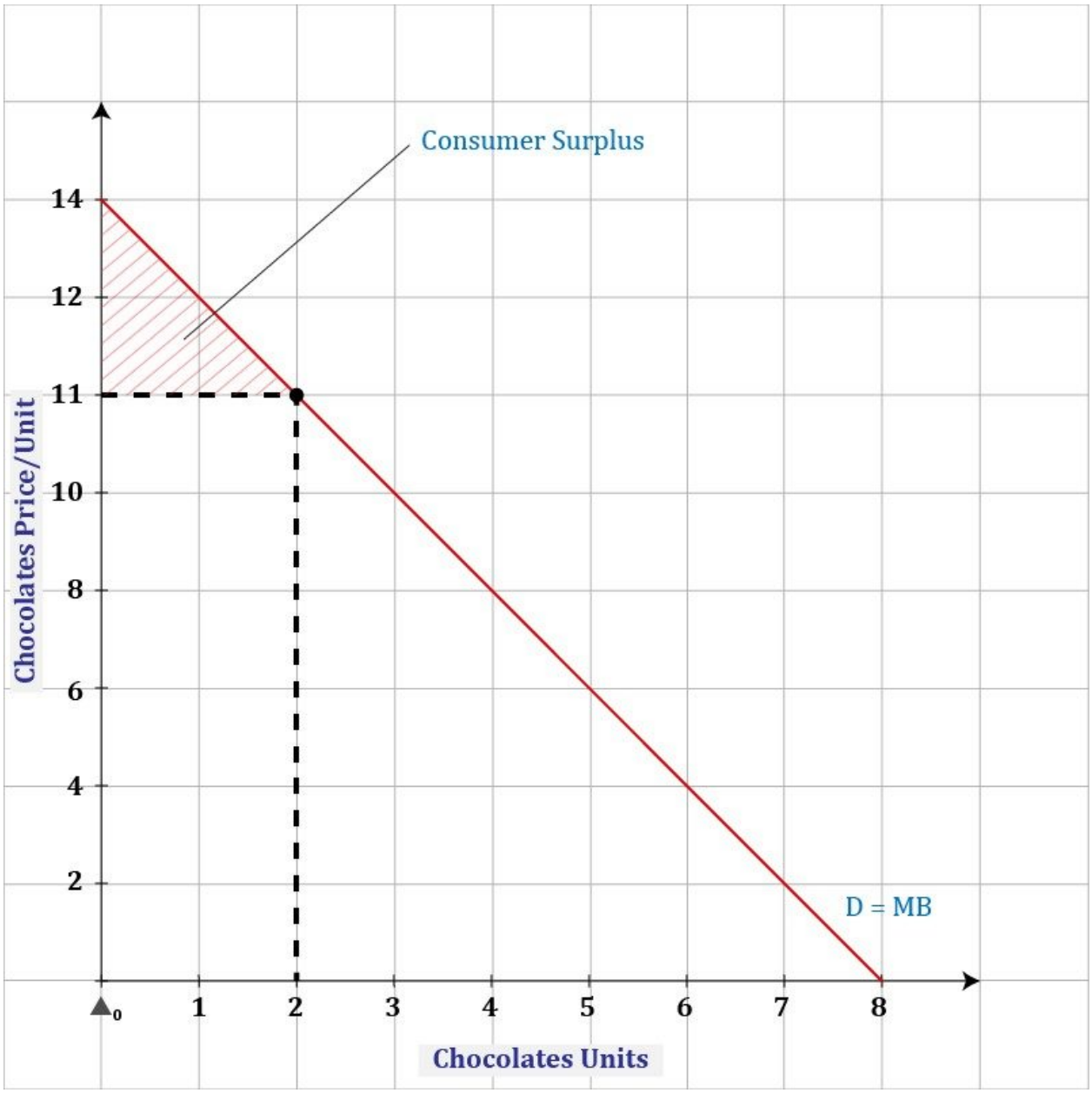
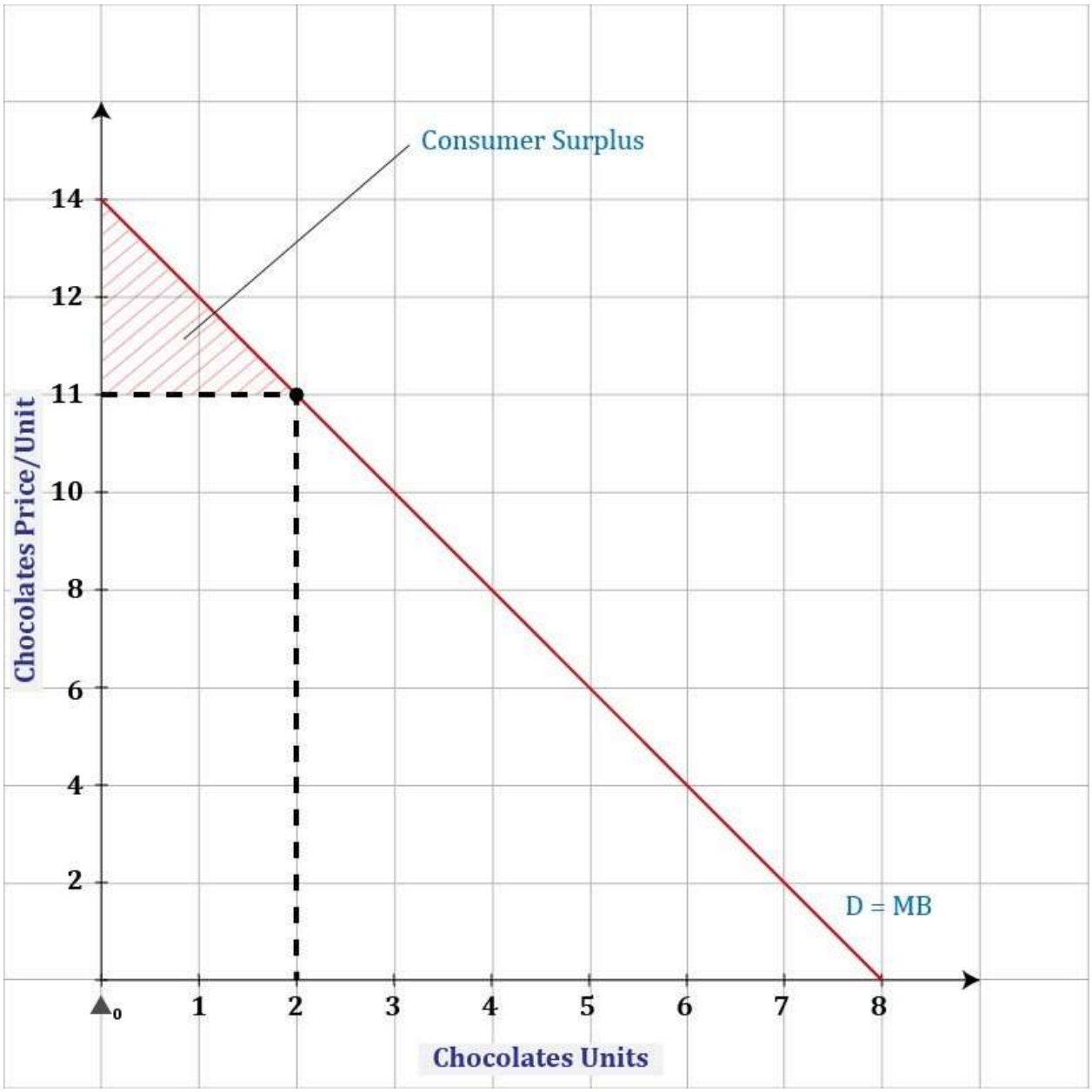


Calculating the Total Consumer Surplus



To calculate consumer surplus, account for Δ0 units. In the graph above, the corresponding unit price is $14. It is the market price that consumers are able and willing to purchase a bar of chocolate.

Since the demand curve is linear, the shape formed between Δ0 unit to 2 and below the demand curve is triangular. Therefore, the ordinary formula for finding an area of a triangle is used. The unit items cancel out to leave the result expressed in monetary form.



Total Consumer Surplus Formula

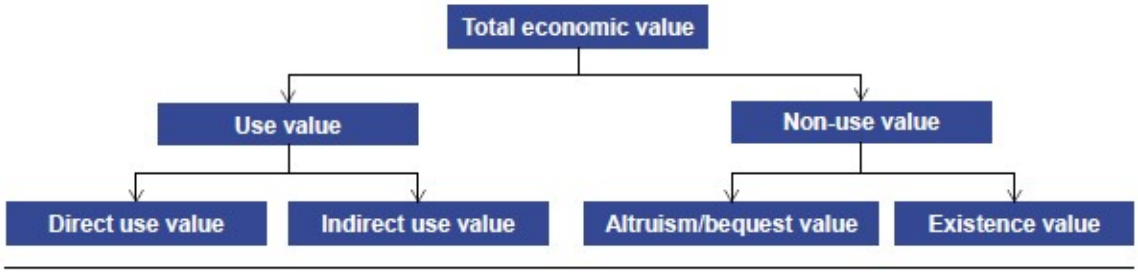
$$\text{Consumer Surplus} = \frac{1}{2} \text{ X } Q_n \text{ X } \Delta P$$

Where:

Qn = Quantity of demand/supply either at equilibrium or the willing purchasing or selling price

ΔP = The difference between the price at equilibrium or at the purchasing or selling point and the price at Δ0

CLASSIFICATION OF ENVIRONMENTAL VALUES



What are non-market values?

Another way of classifying environmental values is between market values and non-market values.

The environment plays an important role in supporting the production of goods and services that are sold in markets. For example, soil, pollinating insects and other environmental inputs support food production. Accordingly, aspects of the environment give rise to 'market values'. Some environmental assets, such as land, and services, such as honeybee pollination, are traded in markets and so have an explicit price that reflects their market exchange value. The value of others, such as rainfall or native pollinators, can be estimated based on the contribution they make to market production using production function methods (whereby the value of environmental inputs can be inferred from the contribution they make to the value of the marketed final product).

For example, where clearing native vegetation is expected to lead to greater salinity on nearby agricultural land, hydrologists, agronomists and agricultural economists can estimate the value of the loss of agricultural production. The greatest source of error in making such estimates often arises from incomplete scientific understanding of the impact of environmental changes on production. By contrast, the valuation of the change in production is often reasonably straightforward (at least for small changes), given the existence of market prices (for example, for agricultural produce or agricultural land of different qualities).

The environment, however, also contributes to people's wellbeing in ways that do not directly involve markets. Many people enjoy spending time in natural settings, or derive satisfaction from the existence of wilderness areas or natural ecosystems. This means that people value aspects of the environment, in the sense that they would be willing to give up something else of value to continue to enjoy them, or to ensure they are available for future generations. Economists use the term 'non-market' to denote these types of values. some use values are non-market values (for example, recreation often is) and non-use values are almost always non-market values.

There are a few things worth noting about non-market values. First, they cannot be estimated by any direct reference to market prices, which makes valuation much harder.

Second, there is not always a behavioural trace that is suggestive of these values. For example, if someone often goes bushwalking in the Ku-ring-gai Chase National Park it may be possible to infer the recreational value they place on the park by observing the amount of money and time they devote to visiting it. However, if someone values the existence of Ningaloo Reef but does

not visit it they might not exhibit any behaviour from which this value could be inferred. It follows that scientific or other experts may have no genuine capacity to estimate some types of non-market values unless they ask people about them. Or as one analyst put it, the relevant experts are the public itself (Hanemann 1994).

Third, non-market values, as usually conceived by economists, are a human-centred construct. Some commentators raise ethical objections to valuing the environment in this way, as they argue that the environment has 'intrinsic value' that is unrelated to human preferences (Spash 1997). Full understanding of the concept of non-market value may remove some of these objections. This is because where people's ethics lead them to be willing to altruistically forgo some of their resources for the sake of environmental improvement, this does get counted as non-market value.

However, those who believe decisions concerning the environment should be settled through debating ethical perspectives, rather than taking each individual's preferences as given, are likely to remain opposed to economic approaches to valuation. That said, it is not clear how the concept of intrinsic value could be satisfactorily applied. One problem is that once one environmental asset is assigned intrinsic value, it is difficult to see how unavoidable trade-offs with other environmental, cultural or social assets that are also afforded intrinsic value could be resolved.

Finally, while many non-market values relate to the environment and these are the focus of this paper, non-market values arise in other areas as well. For example, people value good health and shorter travel times.

Why do non-market values matter for policy?

There are many cases where environmental non-market values are relevant to policy analysis — table 1.1 provides some examples. In most of these, there are conflicting uses of the environment, which give rise to a trade-off between market outcomes and non-market outcomes. Valuing outcomes can be useful to inform decisions about these trade-offs.

Non-market values are often associated with 'market failures', such as the existence of public goods or negative externalities (box 1.1). In these cases, markets do not adequately take account of the outcomes — both market and non-market — that people value. For example, a factory might pollute a river because it bears no cost from doing so (a negative externality) and this could affect recreational users of the river (a decrease in non-market values) and production by irrigators (a decrease in market values).

Table 1.1 **Some policy areas where non-market values are relevant[a]**

Policy area	*Some of the market and non-market values at stake*
Air quality	Air pollution, particularly in cities, can cause irritation, illness and loss of visual amenity. Policies that reduce pollution can reduce these negative effects, thereby producing non-market benefits. The trade-off is that these policies can also impose market costs, such as those associated with fitting pollution control devices, switching to more expensive fuel sources and banning particular industries from urban areas.
Water quality	Stormwater from agricultural and urban areas, and water discharged from factories and treatment plants, can pollute rivers, which can degrade valued ecosystems and reduce recreational enjoyment of them. There is a trade-off between the market costs associated with meeting more stringent water quality targets (such as the cost of upgrading water filtration systems and funding government programs to improve water quality) and the non-market benefits from less polluted water bodies.
Water allocation	Choices must be made about the proportion of water resources to allocate to consumptive uses (such as irrigation and household use) and to environmental uses (such as flushing pollutants or maintaining the health of wetlands). There is a trade-off between the market value of consumptive uses and the non-market value of environmental uses.
Mining	Mining can require native vegetation to be cleared, affect the health of wetlands through the extraction of groundwater, cause land subsidence and have amenity impacts on local communities. Increasing the stringency of mining regulations can reduce these non-market costs (to zero, if a mine is disallowed). The trade-off is that this can also reduce the profits of mining companies, the incomes of mining workers, and the flow of royalties and taxes to governments.
Native forest logging	Logging of native forests can cause loss of biodiversity and reduced recreational enjoyment. Therefore, there can be a non-market benefit from banning (or limiting) logging, but this comes at the cost of not having access to logs that are valued by wood processing facilities (and ultimately consumers). Both the non-market costs and market benefits of logging vary markedly from one area of forest to another, meaning that it may be sensible to ban logging in some forests but not others.
Waste management	Improper disposal of waste can have negative effects on human health, visual amenity and ecosystems. Reducing these effects can have non-market benefits, but also market costs associated with upgrading landfills, anti-litter programs and recycling.

Methods for valuing non-market outcomes

There are two broad ways to estimate the monetary value of a non-market outcome. **Stated preference** methods use surveys to estimate how much money people would be willing to pay to obtain a non-market outcome, such as a specific environmental improvement due to a policy. **Revealed preference** methods analyse observed behaviour to impute the dollar value that people place on non-market outcomes such as recreation or amenity. 'Benefit transfer' is not a valuation method in itself, but rather a technique for applying available estimates of non-market values to new policy contexts.

Stated preference Stated preference methods involve asking people how much they value a particular non-market outcome. This is done by surveying a sample of people that is considered to be representative of the population. There are two main approaches

• **Contingent valuation** involves asking people to make choices about environmental outcomes and payments that can be used to estimate how much they are willing to pay for a non-market outcome to be provided. This outcome, or 'good', is valued as a whole (for example, the amount of money people would be willing to forgo through additional taxes for improvements in vegetation along a river). Typically, people are asked whether or not they would be willing to pay a set amount of money for the environmental outcome to occur.

• **Choice modelling** (sometimes called choice experiments) involves offering people choices between different options that are made up of sets of attributes or characteristics that describe a policy outcome. For example, attributes might indicate numbers of birds and fish, an area of vegetation, and the cost to the individual or their household. 'Implicit prices' are then estimated for each attribute, reflecting average willingness to pay for an additional unit. The value placed on a particular policy option is the sum of the value of its attributes (the implicit price multiplied by the change in the attribute).

These methods typically provide average per-person or per-household estimates for the survey respondents, which can be extrapolated to the wider population to provide an indication of the total non-market benefits or costs of a policy option. This requires making assumptions about the extent of the population that will be affected by the policy change, and whether people who chose not to respond to the survey would also value the outcomes.

What do stated preference methods do?

Contingent valuation and choice modelling both use surveys to estimate how much individuals are willing to pay for a non-market good. Participants are typically asked to make selections from a set of alternatives ('discrete choices'). Both methods use statistical models, based on random utility theory, to analyse survey data. This includes estimating average willingness to pay for non-market outcomes or specific attributes, and examining how willingness to pay is influenced by income, attitudes or other factors (such as age, gender and education). Contingent valuation uses surveys to estimate the highest amount that people would be willing to pay for a non-market 'good' (which may be a single outcome or a complex set of outcomes). When this method was first used, surveys typically asked people to simply state their maximum willingness to pay. It has since become more common to present people with a set amount of money and ask whether or not they would be willing to pay that amount for the non-market outcome to be achieved (this could be an annual payment or one-off amount). The amount is varied across participants in a way that allows statistical models to be used to calculate average willingness to pay. Another approach involves presenting participants with 'payment cards' and asking them to select a maximum dollar amount from a list. Choice modelling is a more sophisticated technique that was originally developed by marketing researchers, partly to overcome some of the drawbacks with contingent valuation. Individuals are asked to choose their most preferred option from a set of alternatives, each of which consists of a bundle of attributes that comprise the non-market outcome (or, in some cases, asked to rank or rate the options). One of the attributes is the

cost to the survey participant, and each choice set contains an option representing the status quo (no policy change). By varying the levels of the attributes and presenting people with several choice sets, statistical methods can be used to quantify the trade-offs that people make between attributes (including implicit prices). Stated preference methods are built upon several key assumptions. One is that people know how much they would be willing to pay (in terms of forgone income) for higher levels of a non-market good, and that this is constrained by their wealth and preferences to consume market goods. Another assumption is that people answer the survey questions honestly and rationally with these constraints in mind. Like other economic methods, it is also assumed that people are best able to know their own preferences.

Revealed preference

Revealed preference methods use data on people's behaviour to examine the trade-offs they make between money (or market goods) and non-market goods, such as recreation, amenity or improved health outcomes. There are two widely used approaches

• **The travel-cost method** imputes the value that people place on visiting a recreation site by examining how much they spend to visit (including costs of transport, accommodation and park entry) and the cost of their time. These data are used to estimate the consumer surplus that people derive from visiting — a measure of the non-market benefit less the costs they incur.

• **Hedonic pricing** deconstructs the price of market goods that are influenced by non-market outcomes. It involves estimating implicit prices for a number of characteristics that make up the good (in the case of housing, these could be the number of rooms, bushland views or proximity to a landfill). The method has often been used to estimate environmental amenity values by analysing house prices. It has also been used to estimate the value of a statistical life by analysing wages across jobs with different levels of risk.

What do revealed preference methods do?

The travel-cost method uses the 'price' (or cost) that people pay to travel to a particular site (such as a national park) to estimate the value they obtain from visiting. Surveys are used to collect data on the costs people incur, and these data are used to estimate a 'trip generation function' that relates travel costs to visit rates (visits per person or visits from a particular region, depending on the model used). A demand curve is then constructed using several assumptions, including that people would respond to the cost of travelling in the same way that they would respond to a site entry fee, and that the marginal (highest-cost) visitor derives no benefit from visiting in excess of the cost they incur. The Demand curve is used to estimate the amount of consumer surplus associated with visiting the site, or to examine how visit rates and consumer surplus might change if entry fees were increased.

Several assumptions are often made in applying the travel-cost model. One relates to the cost associated with travel time, which is generally not observed. Some studies use a fixed fraction of the wage rate, while others omit time costs from the analysis. Another complication is that people might travel for multiple reasons (such as to visit friends or other recreational sites), making it difficult to attribute costs to the site of interest. Some researchers do this based on the

proportion of trip time spent at that site, while others use multi-site models that allow choices between recreation sites to be modelled explicitly, taking into account the fact that some sites may be substitutes.

Hedonic pricing exploits the fact that some market goods comprise a bundle of attributes that include non-market elements. Most environmental applications use regression analysis to decompose house prices into the contributions that come from key characteristics, including house features (such as size or number of bathrooms), location (such as proximity to schools) and non-market environmental attributes (such as air quality or local amenity). This provides estimates of the implicit 'price' of each attribute, which indicates how much house buyers would be willing to pay for one additional unit of the attribute. Welfare measures such as consumer surplus and willingness to pay for a larger change in the attribute have rarely been estimated because of statistical complications and the strength of assumptions required.

The hedonic pricing method is based on the theory that housing attributes have implicit prices and house buyers seek out higher or lower levels of a particular attribute such that the implicit price equals their marginal willingness to pay. Several assumptions are required to estimate these implicit prices. One is that all attributes are fully capitalised into house prices. Another is that house buyers are fully aware of the environmental attributes and weigh these up against the prices of all available houses in the market.

Economic Valuation of Environmental Goods and Services

Introduction

The economic growth is based on wealth creation, based on a process of dominance and transformation of the Nature. The modern society is guilty of wild exploitation of natural resources, neglecting the damages of productive activities. The demand and improper use of the natural resources increases daily. With this speedy environmental harm, environmental protection stands out as one of the current and future major challenges for humanity. The economic appraisal of environment results of the increasing concern with protection and preservation of natural resources and consumers' requests for quality industrial products, simultaneous with the reduction of social welfare, as consequence of the quality and amount of these resources. The economic appraisal emerges as a measuring tool of environmental goods and services and of the impacts of environmental degradation and depletion, determining the direct and indirect costs and benefits of qualitative and quantitative changes. It is gathering importance in the evaluation of investment projects, governmental policies and international trade.

Based on the externality notion, Foladori (1997) defends that negative trends inherent to free market can be beated through environmental appraisal with the inclusion of prices in economic analysis, via policies that attenuate environmental problems. Schweitzer (1990) beliefs that environmental appraisal is fundamental to prevent the depletion of natural resources. The environmental appraisal emerges as a set of techniques and methods to quantify the expectations of benefits/costs derived from the use of environmental assets, carrying out benefittings or infliction of environmental damages. The economic value of an environmental good consists of

the estimate of a monetary value for this good, in opposition to other available goods. However, some times, it's difficult to aggregate all the effects in a single indicator. The economic value of environmental resources (EVER) results from its attributes, and these can be associated to the use (direct, indirect and option) or non-use of the resource, i.e., its simple existence. EVER purposes a fee for environmental resources' use and/or preservation. The genesis is the protection of current and future generations' interests. Thus, use value (UV) is the value attributed by people who use or usufruct of the environmental good to satisfy their needs. The non use value (NUV) is dissociate of the use because it derives from a moral, cultural, ethical or altruistic position regarding the rights of existence of other living species or the preservation of natural assets although that do not represent current or future use for them. While slightly different classifications exist, they result the same. Still, controversy subsists regarding existence (EV) and option (OV) values, since the EV represents the individual will to preserve a set of environmental resources for future generations' direct and/or indirect use. Thus, the conceptual question is if a value defined like so is closer associated with the OV or the EV. Equally, the legacy value (in this definition mixed with the EV) can be independent (Figure1). However, for EVER matters that the individuals point out the most trustworthy values possible, independently of the current or future use.

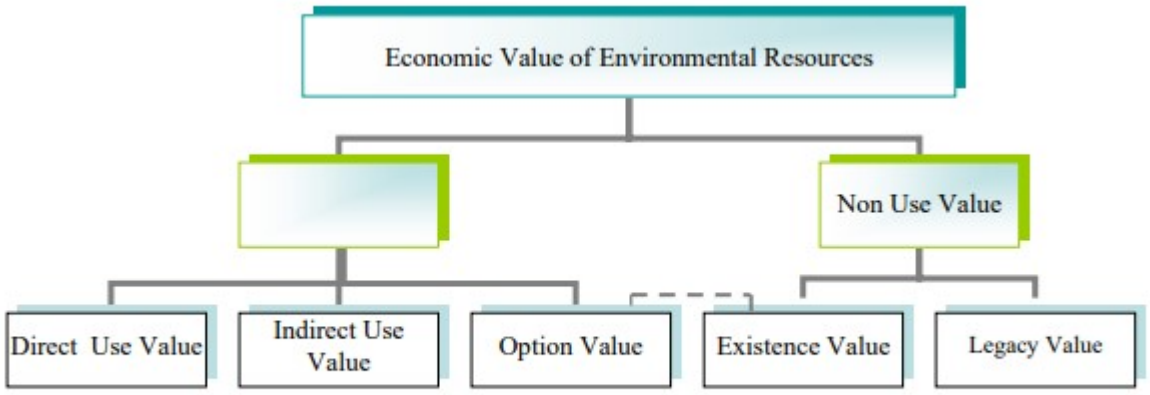


Figure 1: Different economic values of environmental resources

The environmental appraisal difficulty increases inversely as function of the resources' use. The choice of the criterion depends on the knowledge of the ecological dynamics of the study object, the purpose of the valuation, the availability of information and the hypotheses adopted. Environmental economics classifies the valuation techniques in production function methods – marginal productivity method and markets of substitute goods method – and demand function methods – methods that utilize markets of complementary goods (hedonic prices and travel costs methods) and hypothetical markets (method of contingent valuation). May and Motta (1994) refer that production function methods analyze environmental resources associated to the production of a private good and, generally, assume that supply variations do not influence market prices. The demand function methods admit that changes in resource availability modify individual wellbeing and, therefore, it's possible to identify individual measures of Willingness to Pay (WTP) or Willingness to Accept (WTA) regarding to these variations. These are the methods under this study review.

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SCHOOL OF BUILDING & ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT – III – COST BENEFIT ANALYSIS FOR BUILDING & INFRASTRUCTURE PROJECTS-SARA5401

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Conducting a well-executed CBA requires you to follow a logical sequence of nine steps.

STEP 1: SPECIFY THE SET OF OPTIONS

Identify a range of genuine, viable, alternative policy options to be analysed. You must consider at least three options, one of which must be non-regulatory. Your agency is responsible for the choice of options. A 'do nothing' or 'business as usual' option will usually provide the *base case* against which the incremental costs and benefits of each alternative are determined. In some cases, doing nothing may be the best option available. Only costs and benefits that would not have occurred in the base case should be included in the CBA.

STEP 2: DECIDE WHOSE COSTS AND BENEFITS COUNT

For most regulatory proposals, measuring the national costs and benefits is appropriate, rather than measuring any international impacts. That is, as far as is practical, you should count the costs and benefits to all people residing in Australia.

STEP 3: IDENTIFY THE IMPACTS AND SELECT MEASUREMENT INDICATORS

Identify the full range of impacts of each of the options. It is important to identify the incremental costs and benefits for each option, relative to the base case (which will normally be 'what would happen if the current arrangements were to continue?').

Where relevant, the base case should be forward-looking, recognising that the world in which the regulation will be implemented may differ from the current situation (key variables may change in the future, meaning that current or historical parameters may not be the most relevant benchmark). That is, the base case should not simply assume that nothing will change over time—changes that can be reasonably expected should be recognised when identifying impacts of each option.

All the effects of a proposal that are considered desirable by those affected are benefits; all undesirable effects are costs. CBA requires you to identify explicitly the ways in which the proposal makes individuals better or worse off.

The choice of indicators to measure the impacts depends on data availability and ease of monetisation. For example, a regulatory proposal may reduce risks of a hazard. Its positive impact could be measured in terms of a reduced number of accidents. The benefit from accidents avoided could be valued in dollars (see Step 5).

STEP 4: PREDICT THE IMPACTS OVER THE LIFE OF THE PROPOSED REGULATION

The impacts should be quantified for each time period over the life of the proposed regulation. The total period needs to be long enough to capture all the potential costs and benefits. Because of the uncertainty involved in forecasting costs and benefits over long periods, exercise caution when adopting an evaluation period longer than, say, 20 years (although some environmental regulation may merit the use of a longer time horizon).

Predicting future impacts is difficult. There will always be some uncertainty about the outcome of a proposed regulation. Conducting an assessment of uncertainties should be a

standard component of the evaluation of any major proposal. This means that you assess expected values and variability of cost and benefit flows, as well as taking downside risks into account.

A CBA should present the best estimates of expected costs and benefits, along with a description of the major uncertainties and how they were taken into account. You need to set out how costs and benefits are likely to vary with general economic conditions and other influences. For example, would large relative price changes (such as a rise in energy prices or real wages) significantly change the net benefits from the regulatory proposal? If so, what price path might be expected? In general, your CBA should not just assume that the net benefits for one year will be repeated every year.

Although it is difficult to predict what the effects of a proposed regulation might be in 10 or 20 years—or in some cases, even to attach objective probabilities to various scenarios—decisions require some assumptions to be made. A CBA should make those assumptions transparent. When you explicitly consider and justify the assumptions underlying the forecasts, it improves implementation planning and identifies where more effort should be made to improve the analysis. It is a first step towards dealing with the uncertainties that the regulatory proposal may create.

STEP 5: MONETISE (PLACE DOLLAR VALUES ON) IMPACTS

Assigning a net dollar value of the gains and losses of a regulatory initiative for all people affected is one useful way to measure the effects of a proposed change. Measurement of costs and benefits in this way is sometimes referred to as *monetising* costs and benefits.
The amount an individual would pay to obtain (or avoid) a change (if that were necessary or possible) is one measure of the value of that change to them. The value could be positive or negative depending on whether the change makes them better or worse off. Summing these values across all affected people gives the community's total willingness to pay for the change. If the sum is positive, the change increases efficiency. The costs and benefits to all people are added without regard to the individuals to whom they accrue: a $1 gain to one person cancels a $1 loss to another.

This 'a dollar is a dollar' assumption enables resource allocation to be separated from distribution effects—or efficiency from equity effects. That does not mean that distributional considerations are unimportant or should be neglected. It means that they should be brought into account as a separate part of the overall analysis of the proposal in question—which may be more important than the resource allocation assessment, but should be distinct from it. Dealing with equity issues is discussed in more detail below in the 'Accounting for equity' section.

Dollar values can be estimated from observed behaviour. You can measure the value people place on something by observing how much they actually pay for certain goods or services, and the quantities of those goods and services that are consumed. Market behaviour reveals people's valuations (or is at least a guide to them). For example, if a consumer pays $3.50 for a cup of coffee, the value they place on the coffee is at least $3.50 (it will likely be higher).

That said, monetisation, or more general quantification, can be difficult because impacts are sometimes uncertain, some are difficult to value in dollar terms, and some are both uncertain and difficult to value. Environmental goods or safety provisions are typical examples of goods that are difficult to place dollar values on, as they are typically not traded in markets. Various methods for estimating the value of nonmarket goods and accounting for uncertainty in CBAs are outlined below in the 'Dealing with costs and benefits that are difficult to value' section.

The fact that some impacts may be very difficult to quantify in dollar terms does not invalidate the CBA approach. In such cases, a detailed qualitative analysis will often be most appropriate in place of dollar values. Your qualitative analysis should be supported by as much evidence and data as possible to increase the transparency of the report and to assist the decision maker in choosing between alternative options.

STEP 6: DISCOUNT FUTURE COSTS AND BENEFITS TO OBTAIN PRESENT VALUES

Why discount?

The need to discount future cash flows can be viewed from two main perspectives, both of which focus on the opportunity cost of the cash flows implied by the regulation. The first perspective is the general observation that individuals prefer a dollar today to a dollar in the future. This is most obvious in the fact that banks need to pay interest on deposits to entice individuals to forgo current spending. This general preference for current consumption is known as the 'rate of time preference' and relates to all economic benefits (and costs), not just those that are financial in nature.

Since individuals are not indifferent between cash flows from different periods, those flows cannot be directly compared. For monetised flows to be directly comparable in a CBA, those costs or benefits incurred in the future need to be discounted back to current dollar terms. This reflects society's preferences, which place greater weight on consumption occurring closer to the present.

The second perspective is that flows of costs and benefits resulting from a regulation also have an opportunity cost for investment. When regulations impose costs on individuals or businesses, those costs will need to be funded in some way. This funding imposes costs on the affected party, either through the interest paid for borrowing the money, or the returns forgone when the funds are not used for other purposes.

The regulation will therefore only be beneficial when it provides a return in excess of the cost to society of deferring consumption, or of the return that could have been earned on the best alternative use of the funds. By applying a discount rate to future cash flows, the required rate of return is explicitly taken into account in the net present value calculation.

Either approach demonstrates that the need to discount future cash flows can be viewed in terms of the opportunity cost of the cash flows, whether this is the cost of delaying consumption or the alternative investment opportunities forgone. Since most of the costs and benefits of regulatory proposals are spread out over time, and their value depends on when they are received, discounting is crucial to CBA.

The rate that converts future values into present values is known as the discount rate. If the discount rate were constant at r per cent per year, a benefit of B_t dollars received in t years is worth $B_t/(1+r)^t$ now. Box 1 provides an example of how to calculate net present values. The *Handbook of cost–benefit analysis* provides more guidance.

Accounting for inflation

Inflation is another reason that a dollar in the future is worth less than a dollar now. A general rise in the price level means that a dollar in the future buys fewer goods. Analysts conducting a CBA have the choice of whether to include future cash flows in terms of their actual monetary value at the future date (the 'nominal' value) or in terms of their current dollar value (the 'real' value). However, since all cash flows need to be converted to current dollar terms to be comparable in a CBA, it is usually simplest to adopt the latter approach.

CBA measures the value people place on various outcomes, preferably using their willingness to pay as revealed by their market behaviour. Consequently, the preferred approach is to base the discount rate on market-based interest rates, which indicate the value to the current population of future net benefits. Market interest rates determine the opportunity cost of any capital used by the Government's regulatory proposal—that is, what it would have produced in its alternative use.

There is uncertainty about the appropriate discount rate to use for regulatory proposals. It is uncertain what the alternative uses for capital used by a proposal would have been, and what the capital would have produced in those uses.

Box 1: Calculating net present values

To determine the net present value (NPV) of an option, the costs and benefits need to be quantified for the expected duration of the proposal.

The net present value is calculated as:

$NPV = (B_t-C_t)/1+r)^t)$

where

B_t = the benefit at time t

C_t = the cost at time t

r = the discount rate

t = the year

T = number of years over which the future costs or benefits are expected to occur (the current year being year 0).

Consider an option that will require industry to install new equipment to limit air pollution. The equipment costs $5 million to install and will operate for the following four years. Ongoing (annual maintenance) costs to business are $1 million a year (in constant prices). The benefits are estimated at $3 million a year (in constant prices. The discount rates are 3 per cent, 7 per cent and 10 per cent.

Year	Costs (C_t)	Benefit (B_t)	Annual net benefit (B_t-C_t)	Net Present Value		
				3%	7%	10%
Year 0	5	-	-5	-5.00	-5.00	-5.00
Year 1	1	3	2	1.94	1.87	1.82
Year 2	1	3	2	1.89	1.75	1.65
Year 3	1	3	2	1.83	1.63	1.50
Year 4	1	3	2	1.78	1.53	1.37
Net present value of proposal				**2.43**	**1.77**	**1.34**

The discount rate for regulatory interventions

OBPR requires the calculation of net present values at an annual real discount rate of 7 per cent. As with any uncertain variable, sensitivity analysis should be conducted (see below for more information on sensitivity testing), so in addition to the 7 per cent 'central' discount rate, the net present values should also be calculated with real discount rates of 3 per cent and 10 per cent. If the sign of the net present value changes, the sensitivity analysis reveals that the choice of discount rate is important. This information should be highlighted in the summary of the CBA, as it is an important caveat for the analysis.

In some cases, it may be desirable or appropriate to present the results of the analysis using another, different, discount rate. For example, if a well-known piece of international research uses a particular discount rate in presenting its results, it would be sensible to use the same discount rate in analyzing Australia's domestic impacts, to give a sense of the relative scope

of the impacts in Australia compared to the results in the international study. Where there is a research-related reason for using a different discount rate, the analysis can be presented at that discount rate in addition to the 3, 7 and 10 per cent scenarios described above.

Harrison (2010), among others, provides a more detailed discussion of the issues surrounding the choice of discount rate.

STEP 7: COMPUTE THE NET PRESENT VALUE OF EACH OPTION

The net present value (NPV) of an option equals the present value of benefits minus the present value of costs:

NPV = PV(B) – PV(C)

If the NPV is positive, the proposal improves efficiency. If the NPV is negative, the proposal is inefficient. If all costs and benefits cannot be valued in dollars, you should outline why the non-monetised costs and benefits are large or small relative to the monetised impacts.

STEP 8: PERFORM SENSITIVITY ANALYSIS

There may be considerable uncertainty about predicted impacts and their appropriate monetary valuation. Sensitivity analysis provides information about how changes in different variables will affect the overall costs and benefits of the proposed regulation. It shows how sensitive predicted net benefits are to different values of uncertain variables and to changes in assumptions. It tests whether the uncertainty over the value of certain variables matters, and identifies critical assumptions.

If sensitivity analysis is to be useful to decision makers, it needs to be done systematically and presented clearly. Common approaches to sensitivity analysis include the following:

- *Worst/best case analysis*: The base case assigns the most plausible values to the variables to produce an estimate of net benefits that is thought to be most representative. The worst, or pessimistic, scenario assigns the least favourable of the plausible range of values to the variables. The best, or optimistic, scenario assigns the most favourable of the plausible range of values to the variables. If the pessimistic scenario gives an NPV below zero, you will need to investigate the critical elements driving the value of the regulatory proposal, using the following two techniques.
- *Partial sensitivity analysis* examines how net benefits change as one variable varies over a plausible range (holding other variables constant). It should be used for the most important or uncertain variables, such as estimates of compliance costs, forecasts of benefits and the discount rate. It may be important to vary the values assigned to ‘intangibles’, especially when the assumed values are controversial. Partial sensitivity analysis clarifies for decision makers how the CBA results are affected by uncertainty about the level or value of a variable. If you find that varying a parameter has large effects on the net benefits from the proposed regulation, uncertainty about its value becomes important.
- *Monte Carlo* sensitivity analysis creates a distribution of net benefits by drawing key assumptions or parameter values from a probability distribution. See Boardman et al. (2010, pp. 181–184) for more details. While this is a more statistically robust approach to sensitivity

analysis, care needs to be taken in adopting reasonable and justified assumptions about the probability distributions that have been assumed.
If the sign of the net benefits does not change after considering the range of scenarios, there can be confidence in the efficiency effects of the proposal.

STEP 9: REACH A CONCLUSION

You should summarise the results of the CBA. The option with the highest net benefit should be your recommended option. Given that NPVs are predicted (average) values, the sensitivity analysis might suggest that the alternative with the largest NPV is not necessarily the best alternative under all circumstances. For example, you might be more confident in recommending the option with a lower expected value of net benefits, but with a smaller chance of imposing a significant net cost on the community (lower 'downside risks').

Your conclusion should include the time profiles of costs, benefits and net benefits, their NPVs, the discount rate used, information on the sensitivity of estimated impacts to alternative assumptions, a list of assumptions made, and how costs and benefits were estimated.

What is life cycle costing?

Life cycle costing, or whole-life costing, is the process of estimating how much money you will spend on an asset over the course of its useful life. Whole-life costing covers an asset's costs from the time you purchase it to the time you get rid of it.

Buying an asset is a cost commitment that extends beyond its price tag. For example, think of a car. The car's price tag is only part of the car's overall life cycle cost. You also need to consider expenses for car insurance, interest, gas, oil changes, and any other necessary maintenance to keep the car running. Not planning for these additional costs can set you back.

The cost to buy, use, and maintain a business asset adds up. Whether you're purchasing a car, a copier, a computer, or inventory, you should consider and budget for the asset's future costs.

Life cycle costing process

Conducting a life cycle cost assessment helps you better predict how much your business will pay when you acquire a new asset.

To calculate an asset's life cycle cost, estimate the following expenses:

1. Purchase
2. Installation
3. Operating
4. Maintenance
5. Financing (e.g., interest)

6. Depreciation
7. Disposal

Add up the expenses for each stage of the life cycle to find your total.

You might use past data to help you create a more accurate cost prediction. To simplify the process, start with your fixed costs. Fixed costs for businesses are the expenses that stay the same from month to month. Then, estimate variable costs, which are expenses that change.

Life cycle costing process for intangible assets

You can also use life cycle costing to determine how much your intangible assets will cost. Intangible assets are non-physical property, such as patents, your business's brand, and your reputation.

Although it is more difficult to add up the whole-life cost of an intangible asset than a tangible asset (physical property), it's still possible. Consider the total cost of acquiring and maintaining an intangible asset.

For example, patents cost thousands of dollars. You might also need to hire a lawyer to help you obtain one. And, you will need to pay fees to maintain your patent.

Or, consider your business's brand. You might spend money on all the things that go into creating your brand, such as developing a logo, registering your name, and setting up a small business website. Further, you will spend money on marketing and maintaining your brand.

Life cycle costing assessment example

Let's say you want to buy a new copier for your business.

Purchase: The purchase price is $2,500.

Installation: You spend an additional $75 for setup and delivery.

Operating: You need to buy ink cartridges and paper for it, so you estimate you will spend $1,000 on these supplies over the course of its useful life. And, you expect the total electricity the copier will use to be $300.

Maintenance: If the copier breaks, you estimate repairs will total $450.

Financing: You purchase the copier with your store credit card, which has an interest rate of 3.5% per month. You pay off the printer the next month, meaning you owe $87.50 in interest ($2,500 X 3.5%).

Depreciation: You predict the copier will lose value by $150 each year.

Disposal: You estimate it will cost $100 to hire an independent contractor to remove the copier from your business.

Although the purchase price of the copier is $2,500, the life cycle cost of the copier could end up costing your business over $4,500.

Purpose of the life cycle cost analysis

As mentioned, conducting a life cycle cost analysis helps you estimate how much an asset will cost you over the course of its life.

Take a look at some of the reasons why knowing an asset's total cost can guide your business decisions.

1. **Choose between two or more assets**

Using life cycle costing helps you make purchasing decisions. If you only factor in the initial cost of an asset, you could end up spending more in the long run. For example, buying a used asset might have a lower price tag, but it could cost you more in repairs and utility bills than a newer model.

Life cycle cost management depends on your ability to make a smart investment. When you are deciding between two or more assets, consider their overall costs, not just the price tag in front of you.

2. **Determine the asset's benefits**

How do you know if you should buy an asset? Generally, you weigh the pros and cons of your purchase. But if you only consider the initial, short-term cost, you won't know if the asset will benefit your business financially in the long run.

By using life cycle costing, you can more accurately predict if the asset's return on investment (ROI) is worth the expense. If you only look at the asset's current purchase cost and don't factor in future costs, you will overestimate the ROI.

3. **Create accurate budgets**

When you know how much an asset's total price is, you can create budgets that represent your business's actual expenses. That way, you won't underestimate your business's costs.

A budget is made up of expenses, revenue, and profits. If you underestimate an asset's cost on your budget, you are overestimating your profits. Failing to account for expenses can result in overspending and negative cash flow.

Life cycle cost is the cost that is associated with the project from the beginning of the project to the end of its useful life and beyond. It includes the cost of acquiring the project, operating it, and disposing of it at the end of its useful life. It may even include money spent after the project's useful life that is a result of the project's existence and effects.

Normally the cost of a project is considered only from the beginning of the project to its end. This is reasonable because the project team is formed to carry out the work of creating the project, deliver the deliverables, and do it within the schedule and cost goals of the project. This is really a narrow view because there are many costs that may occur for the stakeholders as the result of decisions made within the project but occurring after the project has been completed. Life cycle cost considers all these costs.

For example, the project team is able to reduce cost by limiting the number of design reviews. The result of this may be that the design is compromised. The compromised, nonoptimal design may cost the stakeholders many times the money saved by limiting the design reviews. The cost of this will not necessarily occur until the project is delivered and the project team disbanded. Life cycle cost would include this cost.

Life cycle cost is quite important in the justification of projects. The total cost of a project should be considered over the entire life of the project and not just within a fixed period of time.

The cost and benefits of the project must be considered over the life of the project. By this we mean that we must consider all of the effects of the project from beginning to end. If we were building a nuclear power plant and we were to consider only the cost of building the plant and operating it for the twenty-five or so years it would be in operation, we would be very naive. There is tremendous cost associated with decommissioning a nuclear power plant and cleaning up the area where it was in operation and disposing of the radioactive materials that are left. Today we have a legacy of nuclear power plants where this was not done very well. In the 1960s and 1970s many nuclear plants were built with little regard for what would have to be done when they were worn out. Little consideration was given to the disposal of spent nuclear waste, and we still have no workable plan for disposing of it. Many of these facilities probably would not have been constructed if the full cost had been recognized at the beginning of the project.

When project decisions are made, we must consider the effect of these decisions outside the direct area of the project. When cheaper materials are used for a project, it will usually result in a shorter useful life or a product that is more fragile and has higher maintenance costs. Sometimes the application and the desires of the stakeholders are that the cheaper product be made regardless of the future maintenance cost and the shorter useful life. This can be a valid decision.

The important obligation of the project manager and the project team is that the customer and the stakeholders be made aware of these options and that informed decisions are made with the realization that money saved today may cost more in the long run. This again points out the importance of doing a good project justification.

In project justifications, the period of time that should be considered in justifying the project must be long enough to include the recognition of the life cycle costs until they reach a steady

state or go to zero. By doing this in our project justifications we assure that all of the costs of the project are considered. If the client wants the project done at a minimum cost, the justification will show the increases that are going to occur after the project is delivered.

For example, suppose we could do a project two different ways. If we do the project the first way, we will spend the money to make the project robust and long-lasting, which will result in minimum maintenance costs. If we do the project the second way, we will minimize costs by using the minimum amount and strength of material and design the project for minimum cost and sacrifice future maintenance costs. Suppose the first method of doing the project could deliver the project for $2,000,000 and the future maintenance costs were estimated at $100,000 per year for the fifteen years of the project's useful life. The second method could deliver the project for $1,500,000 and the estimated maintenance cost would be $200,000 per year.

As can be seen in this very simplified example, the life cycle cost of the project is much lower if the cost is not minimized in delivering the project.

Least Cost Method

Definition:

The Least Cost Method is another method used to obtain the initial feasible solution for the transportation problem. Here, the allocation begins with the cell which has the minimum cost. The lower cost cells are chosen over the higher-cost cell with the objective to have the least cost of transportation.

Least Cost Method

The Least Cost Method is considered to produce more optimal results than the North-west Corner because it considers the shipping cost while making the allocation, whereas the North-West corner method only considers the availability and supply requirement and allocation begin with the extreme left corner, irrespective of the shipping cost.

Let’s understand the concept of Least Cost method through a problem given below:

Source \ To	D	E	F	Supply
A	5	8	4	50
B	6	6	3	40
C	3	9	6	60
Demand	20	95	35	150

In the given matrix, the supply of each source A, B, C is given Viz. 50units, 40 units, and 60 units respectively. The weekly demand for three retailers D, E, F i.e. 20 units, 95 units and 35 units is given respectively. The shipping cost is given for all the routes.

The minimum transportation cost can be obtained by following the steps given below:

To / Source	D	E	F	Supply
A	5	8 (50)	4	50
B	6	6 (5)	3 (35)	40
C	3 (20)	9 (40)	6	60
Demand	20	95	35	150

1. The minimum cost in the matrix is Rs 3, but there is a tie in the cell BF, and CD, now the question arises in which cell we shall allocate. Generally, the cost where maximum quantity can be assigned should be chosen to obtain the better initial solution. Therefore, 35 units shall be assigned to the cell BF. With this, the demand for retailer F gets fulfilled, and only 5 units are left with the source B.
2. Again the minimum cost in the matrix is Rs 3. Therefore, 20 units shall be assigned to the cell CD. With this, the demand of retailer D gets fulfilled. Only 40 units are left with the source C.
3. The next minimum cost is Rs 4, but however, the demand for F is completed, we will move to the next minimum cost which is 5. Again, the demand of D is completed. The next minimum cost is 6, and there is a tie between three cells. But however, no units can be assigned to the cells BD and CF as the demand for both the retailers D and F are saturated. So, we shall assign 5 units to Cell BE. With this, the supply of source B gets saturated.
4. The next minimum cost is 8, assign 50 units to the cell AE. The supply of source A gets saturated.
5. The next minimum cost is Rs 9; we shall assign 40 units to the cell CE. With his both the demand and supply of all the sources and origins gets saturated.

The total cost can be calculated by multiplying the assigned quantity with the concerned cost of the cell. Therefore,

Total Cost = 50*8 + 5*6 + 35*3 +20*3 +40*9 = Rs 955.

Note: The supply and demand should be equal and in case supply are more, the dummy source is added in the table with demand being equal to the difference between supply and demand, and the cost remains zero. Similarly, in case the demand is more than supply, then dummy destination or origin is added to the table with the supply equal to the difference in quantity demanded and supplied and the cost being zero.

Introduction

Cost-benefit analysis (CBA) is the principal analytical framework used to evaluate public expenditure decisions. CBA said to have had its origins in the 1930s with the WPA water projects (dams) in the western U.S. There was a need to justify these projects to the taxpayers and Congress, hence CBA.

A greater demand for CBA is initiated by Executive Order 12291 issued by Reagan in 1981 requiring CBA on all government projects costing $100 million or more. Also, the need for CBA is illustrated by the fact that nearly all western countries require CBA and have developed protocols for CBA. CBA is a very common form of analysis for governments.

CBA and Economic Efficiency

Purpose of CBA: The general purpose of CBA is to help government & society better allocate their scarce productive resources.

CBA's Social Goal: The societal goal behind CBA is to achieve maximum economic efficiency.
What is economic efficiency?: economic efficiency requires that B>C. Efficiency is concerned about economic inputs vs. economic outputs.

CBA Rules: Thus, CBA analyses adheres to the following 2 simple rules:

1. If there are no constraints on inputs, adopt all projects that have positive net benefits (i.e., NPV).

2. If there are constraints (e.g., budgets) which limit the number of projects you can choose; then choose the combination of projects that maximizes net benefits (i.e., NPV).

3. Corollary: never adopt a project with negative net benefits.

Applying the Fundamental Rules

Next we will illustrate the application of the fundamental rules with 4 examples.

Example 1: Accepting or rejecting a single project.

This is simple. Remember, in the single project choice situation, adopt the project if the NPV > 0. If NPV is negative, reject the project.

But what about the alternative of no project?
No project is always implied by your analysis. CBA compares the additional benefits and costs with the project to benefits and costs without the project. CBA examines only the incremental costs, benefits, damages due to the project, not those that would occur anyway given a passage of time.

Thus, the proper comparison is:
1) costs and benefits with the project vs.
2) cost and benefits without the project.
With vs. without always insures a no project comparison**.**

The potential pitfall is that you will make a before vs. after comparison rather than with vs. without. In the future outputs will be different than they are now even w/o the project. So, you always have to take care to compare the situation with vs. without the project. Never analyze before vs. after.

Example 2: Choosing from one project from a number of mutually exclusive alternatives.

Solution: chose the one project that will "max net benefits."

Example 3: Choosing the appropriate scale of a project

Rather than a discreet choice set, as with the previous problem, this is a continuous choice set. Example: application of fertilizer or insect control to agricultural fields. You can apply varying amount of control. What is the optimal level of the application?

This is, in practice, a very difficult sort of problem, because you must know the continuous range of response to a range of treatments. Requires lots of production information. Here we simplify greatly.

We normally use a graphical solution to illustrate this problem. [See example with fig.1.1, p. 14 in Boardman.] In real practice, quantitative information would be developed.

Problem: Farmer want to know how much fertilizer to apply to his crops. Fertilizer costs are rising continuously in a nonlinear rate; indicates increasing costs. Total cost = the cost of fertilizer.

The value of growth response (benefits) is non-linear ($ value of increased crops. production). This curved TB line exhibits decreasing marginal returns from fertilization.

Choice Rule: expand the project until MC=MB; also the same as MNB=0. In doing this, you are maximizing net benefits; this is the greatest distance, hence difference, between total costs and total benefits.
Calculus rules: equate first derivatives equal dTB/dQ = dTC/dQ;

Or, alternatively, set dNB/dQ=0
The fertilizer solution: Optimal amount (cost) of fertilizer is inferred from the Y axis.

Example 4: Accepting or rejecting a number of projects when initial cost is a constraint.

The first rule said accept all projects with a positive net benefit if there were no constraints on inputs. But now we have constraints on initial capital. How do we choose among the many projects?

The situation: The Wildlife Commission is considering a number of investment projects. Each is desirable, however, the Commission has a constraint on the initial (i.e., current year) investment capital it can spend. It can probably choose more than one project, but probably not all of them.
Solution: compute B/C ratio and array project in descending order of B/C ratios. Select projects until capital is exhausted.

Our objective is still to max net benefits. But with a constraint on initial investment, we will need some help from B/C ratio in finding a solution. B/C ratio can show us where we get the greatest benefits relative to initial investment.

IV. The Benefit/Cost Ratio

We introduced B/C ratio in the last example to help rank projects in order to max net benefits.

What about B/C ratio itself as a criteria for choosing mutually exclusive projects?
You have heard about B/C ratio and the adage accept the project if B/C ratio > 1,
meaning that the benefits are greater than the costs. It has historically been a very popular measure of investment performance for govt. projects.

Key Question: are B-C and B/C consistent when choosing one project from among mutually exclusive projects? Will the 2 criteria always lead to the same conclusion regarding the one best project?

The answer is no. The results may be conflicting. Thus: If projects are mutually exclusive (you must choose only one), B/C and B-C could give inconsistent, conflicting results.

What to do? Maximize net benefits is the favored criterion.

Another characteristic of B/C ratios.
Benefits are an algebraically positive entry in our accounting system. And costs are negative. But what about accounting for environmental damages like those stemming from air pollution?

For example, suppose the government wants to build a coal-fired power generation plant and they anticipate some air pollution damage to the surrounding environment.
It is possible in CBA to account for these environmental damages as either:

1) a positive cost, or 2) a negative benefit. There are great debates about which is appropriate.

Q: Will this accounting decision affect the analysis?
A: Not with max net benefits as the criterion. If you use max net benefits criterion; damages net-out either way you choose to classify damages (whether as a positive cost or negative benefit).

Conclude: if max net benefits is the criterion, it does not matter if damages are counted as a negative benefit or a positive cost. However, if you use B/C ratio, you must be careful.
Example: Cost=$1; benefits=$4; damage=$2. Make the B/C and B-C calculations first with damages as a positive cost then as a negative benefit and compare.

V. Theoretical Foundations of CBA
As we said, the goal of CBA is to determine economic efficiency (i.e., if B>C?).

Q: Is there any rational basis for saying that B>C is, in fact, the proper criterion for selecting public projects?

Gainers and losers: Decisions regarding public policies can create economic losers and gainers. Almost every alternative to be judged by CBA will have favorable effects on some people and unfavorable effects on others. Almost any project asks one part of society to sacrifice in order to provide for another part of society.

Because social welfare depends upon the satisfaction of all of society: Does the simple standard - benefits must be greater than costs - adequately deal with this issue of gainers compensating losers?
In a nutshell, B>C does deal with gainers and losers in that B>C at least assures that economic surplus could permit gainers to compensate losers. Follow the logic:

From 19th century economist Vilfredo Pareto, we derive the notion of Pareto Efficiency:
a state such that resources cannot be reallocated in order to improve the utility of at least one person without decreasing the utility of others.

Pareto Efficiency requires that gainers must compensation losers. *"cannot be reallocated"*... is the key phrase.

Thus, if Pareto Efficiency is our rationale, then any government project must assure that gainers compensation losers.

But, it is argued that:
1. B>C alone doesn't provide specific guidance for compensation
2. compensation involves interpersonal comparisons about utility that economists cannot make, and
3. administration of actual, full compensation is too costly to consider.

Thus, the Pareto Efficiency, because it says compensation must take place, seems not to justify B>C.

An alternative rationale:
The Kaldor-Hicks Compensation Principle says: *a policy should be adopted only if those who will gain could compensate those who will lose and still be better off.* K-H does not say (as does Pareto Efficiency) that compensation *must* take place, only that it could take place. Thus, K-H says that B>C is valid because it creates enough economic surplus (i.e., B>C) such that compensation of losers by gainers potentially can occur. Thus B>C leads to a potential Pareto improvement.

So equity (i.e., the distributional issue) is not important; CBA is not concerned with equity.
Or is it?
A quote to contemplate: *Economic welfare analysis of policies which do not look at impacts on individual groups in effect usurps the policymaker's authority to make such judgements.*

VI. *Ex ante* vs. *ex post* CBA:
There are 2 general types of CBA analyses: *ex ante* and *ex post*. Ex ante means coming before. Ex ante CBA precedes a project. Ex ante helps to make a goor no-go decision on a single project, or to select the best one of several project before it actually begins.
Strength: Ex ante studies can contribute a lot to the optimal resource allocation question (because this type of CBA precedes the project.)
Weakness: Ex ante studies, because they are based on future benefits and costs, may be based on weak information and may involve a high degree of uncertainty.

Ex post means coming after. Ex post CBAs, therefore, come after a project has been completed.
Strength: They are based on less speculative information (since all costs and benefits have already occurred.)
Weakness: They have less power to influence resource allocation for the current project. But they can affect resource allocation for similar future projects. (If a past project was not cost-beneficial, Congress won't likely fund another like it.)

VII. Accounting Stance and Standing

A decision must be made at the beginning as to the geographic scope of the study: whose costs and benefits to count? The scope could be local, state, regional, national or global. With any scope smaller than global, you can encounter some accounting problems. Mainly, a lot of global transfers (i.e., the cost to group A = the benefit received by group B) show up as local benefits. Examples:

1. local CBA shows employment gains but not attendant employment losses occurring outside the region
2. local government CBA shows increased tax revenues as a benefit but not attendant consumption/savings decreases by citizens.

Beware of these sub-global studies; they can be abusive.

For government CBA, the proper perspective is almost always global (Executive Order 12291: *measure the costs and benefits regardless to whom they may accrue.*).
So, for a global analysis, think of the social project as a single production process where:
inputs = costs, outputs = benefits; and damages = either negative benefits or positive costs.

VIII. Economic vs. Financial Analyses

Government economic CBA analyses are the principal focus of this course. Financial CBA is another type of analysis important in the business world. The private sector has an obvious interest in financial analysis and planning to insure that they make the proper business decisions. We can, however, differentiate economic and financial CBA.
Following is a summary of the difference between economic and a financial CBA analysis (adapted with changes from Brooks, Ffolliott, Gregerson and DeBano, *Hydrology and the Management of Watersheds*, Ch. 14).

Comparison of financial and economic CBA analyses:

	Financial CBA Analysis	**Economic CBA Analysis**
Purpose	Efficiency of private investment	Efficiency of public investment
Focus	Net returns to private group/individual	Net returns to society-at-large
Benefits	Market goods and services	Market, non-market goods and services, or non-uses
Prices	Market or administered	Market, administered or shadow (adjusted or assigned) prices

Taxes	Cost to the firm or individual	Typically treated as a transfer payment (cost to consumer offset by benefit to government); may be administrative costs
Subsidies	Revenue to the firm or individual	Transfer payment: benefit to producers & consumers offset by cost to taxpayers.
Discount rate	Private opportunity cost of capital	Social Discount Rate (assigned by the agency)
Distribution of Benefits (Equity)	Not an issue	Not a principal concern of CBA, but can be an issue for separate analysis

Summary: a financial analysis deals strictly with market-traded goods and services and accountable money flows. Economic analysis examines social benefits and costs, valued at society's willingness-to-pay.

IX. The 10 Steps in a CBA

1. Choose a project evaluation criteria- the most common, most preferred project evaluation criterion is maximization of present net benefits, or perhaps EANB for projects of unequal duration.. However, there are other possible criteria. The analyst must choose the one best suited to his/her objectives.

2. Determine the Accounting Stance - what is the proper accounting perspective for the analyst; whose benefits and costs will count? one person's gain can be another's loss.

General Rule: Economic CBA examines a social production process. There are inputs and outputs in production processes. That which is an input is a cost; the output is a benefit. This is true regardless of " to whomever the cost and benefits may accrue." There can be different perspectives on the same cash flow. The rule: the accounting stance should be from the standpoint of society-at-large.

3. Select the alternative projects - at this step, the analyst must determine if it is a single government project which will undergo CBA, or are their several competing projects. The projects must be identified.

4. Identify the types (not amount, just yet) of physical inputs and outputs - because the CBA project(s) is a production process, there will be physical inputs and outputs. The analyst

must determine the types of inputs it will take to get the job done (natural resources, labor, capital). Determining the outputs of a project, i.e., benefits, can be troublesome. And what will be the output (product) of the action: camper RVDs? timber saved? less driving time? less flood damage due to dam construction? What about all the ancillary benefits? There may also be "bad" outputs: sedimentation from more logging, more traffic congestion, pollution from cars. The "bads" must be accounted for as well as the "good" outputs.

5. Quantify outputs over the life of the project - now you must estimate the amounts of the impacts: how many RVDs? How much timber? How much less flooding and how much less damage to property? How much pollution? How much sedimentation? This is a very difficult phase of the study. One may use: a) studies, b) observation, c) or even estimates by experts.

6. Monetize all inputs and outputs - this is the process of determining the dollar value of benefits and costs. Cost requires valuing inputs at their opportunity cost. Opportunity cost is the best price they could draw in alternative usage. In a market economic, opportunity cost is usually taken to be their fair market price.

Valuing benefits is often more difficult. Benefits for public projects should be valued at society's "willingness-to-pay" for the goods and service in question. WTP does not measure the amount paid for the good/service (i.e., the price) but the total value of the social benefit derived. Price does not always reflect true value. Example: outdoor recreation has a benefit which usually exceeds the park entrance fee paid. Thus WTP for recreation > gate fee (i.e., price). This benefit valuation should ideally be performed for both tangible and intangible goods and services. **7. Select a discount rate** - the analyst must select a rate for discounting future benefits and costs. Often, however these are mandated by the agency.

8. Sum discounted benefits and costs- regardless of the criteria selected, you must discount and sum the values. Computer spreadsheets can help here.

9. Perform sensitivity analysis - sensitivity analysis is an attempt to deal with uncertainty. It can involve varying discount rates or other factors in the analysis, such as physical inputs or outputs, or values of benefits or costs. This will result in a variety of answers rather than one single answer. Often, this is the best way to deal with uncertainty. Give the boss a range of answers.

10. Recommend the preferred alternative - prepare a report and recommend the project(s) that perform the best according to the chosen criterion.

Traditionally, the economic analysis of a project has been undertaken last in a series of studies covering the technical, institutionalorganizational- managerial, social, commercial-marketing and financial aspects (Gittinger, 1982). For the tsetse and trypanosomiasis problem, this approach has recently been formalized with the development of SITE analysis (Doran and Van den Bossche, 2000); SITE is a process for screening strategy options by the four criteria on which the acronym is based:

- Socio-economic
- Institutional
- Technical
- Environmental.

The various options for intervention are then scored and ranked according to these criteria, and conflicts between the results for the different criteria explored. The remit of this paper obviously falls within the socio-economic component. There are a variety of techniques for analysing the economics of interventions in the field of agriculture and livestock production, which have been summarized in the animal health context by Rushton, Thornton and Otte (1999), the possible approaches are also discussed, with specific reference to parasitic diseases of livestock, in Perry and Randolph (1999). The technique that has been most used in the past, and which is favoured by many of the authors in Perry (1999) is some form of social benefit - cost analysis. This can be underpinned as appropriate by the use of a herd model simulating output from the livestock population with the project being implemented and consequently with improved production parameters, and comparing this to the situation in the absence of the project. Integrating epidemiological with economic models is also very helpful, particularly for a vector-borne disease such as trypanosomiasis (see McDermott and Coleman, 2001). Perry and Randolph (1999) emphasize the need to:

- "integrate the products of good epidemiological studies into economic frameworks";
- "integrate techniques for economic analysis and simulation models of animal production and health dynamics within a systems framework".

Published textbooks on the evaluation of animal health programmes, such as Putt *et al.* (1987) and Dijkhuizen and Morris (1997) also support this approach. It remains the most practical tool for analysing and ranking projects according to the relationship between their costs and their expected impact.

At this stage it is appropriate briefly to review some of the main techniques used in benefit - cost analysis which are particularly relevant in the field of tsetse and trypanosomiasis control. The main steps in benefit - cost analysis are:

- quantifying the expected benefits of an intervention over time;
- quantifying the expected costs of an intervention over time;
- comparing these, coming up with a standard measure (net present value, benefit - cost ratio or internal rate of return) that makes it possible to

  - assess the intervention's profitability

  - compare it, or rank it against other possible interventions with which it is competing for funds or which are alternatives for development in the same production sector;

- undertaking sensitivity analyses to examine how sensitive the result is to changes in key assumptions, such as the effectiveness of the disease-control measures, the rate of

adoption of an animal health intervention or the growth of human and livestock populations in the project area.

Social benefit - cost analysis studies the effect of an intervention, usually described as a project, on society as a whole, so it takes into account all the benefits and all the costs, regardless of who spends the money or to whom the benefits accrue. In the tsetse and trypanosomiasis field the benefits tend mostly to accrue to livestock and crop farmers, while the expenditures are usually shared between donors, government and local farmers. While many analyses focus on the total social costs and benefits, increasingly, studies are looking at the effect of interventions from the financial viewpoint of the livestock keepers. Thus, the studies by Woudyalew *et al.* (1999) and Blanc, Le Gall and Cuisance (1995) calculate benefit - cost ratios from the farmer's point of view. New ways of modelling benefits at farm level are also being developed (McDermott, Coleman and Randolph, 2003).

TIME VALUE OF MONEY

A key principle underlying the benefit - cost approach is assigning a lower weighting to future income/expenditure as against current income/expenditure[1]. The rationale for this can be presented in a number of ways.

- Using money has an *opportunity cost*, which banks acknowledge by paying interest to customers for using their money, and charging it when customers borrow the bank's money; in the public sector this opportunity cost exists because projects are competing for scarce public funds and allocating money to one project within a sector usually takes it away from an alternative use.
- In this case, we should select projects which provide a good *return on money invested*, as measured by the compound interest which the benefits add to the costs over time.
- Finally, society places a relative valuation on present as against future income; this is the *social time preference rate*. This rate tends to be high in poor societies where current needs are urgent, and lower in wealthy societies where the future is more secure.

In benefit - cost analysis this relative weighting of present as against future income (the implied interest rate or minimum acceptable return on money invested) is undertaken by using a process called discounting. This process is not just applied in commercial business ventures, but is an integral part of the project analysis process in public sector projects in all areas (see Gittinger, 1982 on agricultural project analysis; Drummond *et al.*, 1997 for human health projects; Putt *et al.*, 1987; Dijkhuizen and Morris, 1997; Rushton, Thornton and Otte, 1999 for animal health projects and discussion in Kristjanson *et al.*, 1999). Discount rates used in agricultural and livestock analysis generally range from 8 percent to 15 percent, and in the field of human health they range from 3 percent to 5 percent (Acharya and Murray, 1997). With the exception of Budd (1999), whose objective was to present the global magnitudes involved rather than undertake an analysis over time, the economic studies of the trypanosomiasis problem cited above, have applied discount rates of 8 percent or over in their analyses. Since the use of discount rates penalizes future benefits as against present costs, the use of high discount rates has been debated in projects that are expected to have very long-term benefits or many "intangible" benefits that are difficult to quantify, in particular in the field of the eradication of infectious diseases in

humans (Acharya and Murray, 1997). The authors conclude that it can sometimes be argued that the selection of human diseases for eradication should be undertaken without discounting using other, very stringent, criteria, and that a proportion of global health funding be set aside for this purpose. Nevertheless, costs should be discounted in order to select the most cost-effective options. However, other writers, even in the field of human health, conclude "technically and theoretically there are good reasons for discounting benefits as well" (as costs) and "discounting health benefits has been advocated as good economic practice in all guidelines on economic evaluation" (Glydmark and Alban, 1997).

As a consequence, it is recommended here that, when dealing with a disease which:

- mainly affects livestock and agricultural production, and
- occurs in a continent where there are huge and urgent alternative demands on finance,

we maintain the convention of using discount rates. In view of the inclusion of tsetse elimination, which would have very long-term benefits, among the options for dealing with trypanosomiasis, the discount rate used in the analysis below was 5 percent rather than the 10 percent which would more usually be applied in the livestock sector.

Discounting has important implications in comparing control and eradication options. This is particularly so in the field of tsetse control where some techniques, such as targets or ground spraying, can be used for either control or eradication. Furthermore, eradicated areas may need to be treated repeatedly because of re-invasion or failure to completely eliminate a tsetse population.

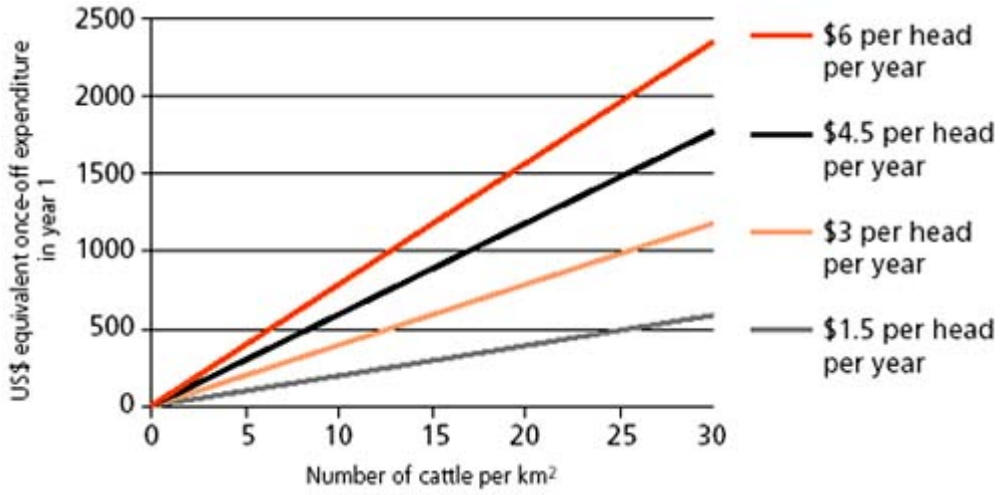
Figure 1 illustrates some of the implications that discounting has for decision-making on options for tsetse and trypanosomiasis control. In this figure, annually recurring expenditures over 20 years are compared to once-off expenditures incurred at the start of a 20- year period. The example used is of expenditures on trypanocides, which are costed at US$1.50 a dose, and then multiplied by the number of cattle per km^2, in order to obtain an annual total cost per km^2 at different cattle population densities. The once-off expenditures could equally well refer to annual recurrent expenditure on tsetse control, for example using pour-ons.

The figures on the *y*-axis show what the equivalent amount spent per km^2 at the beginning of the period would be. Thus, at about 20 cattle per km^2, an annual expenditure of US$6, or four doses of trypanocide, would be equivalent to an initial outlay on tsetse elimination of US$1 500 per km^2. If tsetse elimination cost less than this, it would be the more attractive option, however if it cost more, a very clear argument would need to be presented to show that it was economically justified. Obviously this model simplifies the situation, for example:

- it does not take into account the fact that the cattle population might be increasing during the period;
- it only looks at cost-effectiveness, implying that the two options have equivalent benefits over time, whereas tsetse clearance may be subject to re-invasion, annual control usually does not totally remove the effects of disease, drug resistance can gradually appear;
- it is based on a 20-year time horizon;

- it assumes that tsetse clearance is a once-off expenditure occurring in year one of the project, whereas it may take several years to achieve and be followed by some ongoing annual costs, for example the cost of barriers.

FIGURE 1
Comparing annual to once-off expenditure



Note: Calculated over 20 years at a 5% discount rate

All of these factors could easily be taken into account in a comprehensive benefit - cost analysis, in particular the changes in cattle populations can be tackled using a herd model as outlined below.

Despite these limitations, the analysis is useful in illustrating the basic nature of some of the decisions which have to be made in the field of tsetse and trypanosomiasis control. Similar graphs could be constructed to show:

- the annual benefit per head of cattle which would be needed in order to justify a certain initial outlay on tsetse clearance - again using Figure 1, it implies that if the benefit is expected to be of the order of US$6 per year, the average cattle population per km^2 would have to be about 12.5 in order to justify a once-off expenditure of US$1 000 on tsetse clearance;
- the level of annual expenditure on tsetse suppression for which it would be more economic, if feasible, to switch to tsetse clearance - for example, if suppression costs US$30 per km^2, this would be equivalent to a once-off expenditure of just under US$400 per km^2; if suppression were deemed to be only 50 percent as effective in controlling the disease as permanent clearance, this figure could be adjusted to just under US$800 (400/0.5).

THRESHOLD VALUES

In economics, as in other disciplines, it is often useful for the decision-maker to be able to define threshold values or cut-off points, above which a certain decision is appropriate and below which another becomes valid. In economic and financial decision-making these are often referred to as break-even points. They define the point at which a project "breaks even", meaning that above this point the benefits exceed the costs; below this point the costs exceed the benefits. In the same way that the cut-off point for a diagnostic test can be adjusted to make it either more specific or more sensitive, in economics, the cut-off discount rate chosen can make it possible to give different weights to long-term benefits as against current costs. Also, as in other disciplines, the threshold value has to be interpreted by the decision-maker, and may often consist of a range of values within which it is felt that the result is doubtful. In project appraisal, these "doubtful" projects, are those which should be put at the "bottom of the pile" and only looked at when no better alternatives are found or when circumstances change, such as their score on another of the SITE criteria.

The threshold concept is particularly helpful in assessing the economic viability of different tsetse and trypanosomiasis control schemes. Some of the thresholds are:

- cattle population density at the start of a programme (as seen in Figure 1 this determines benefit levels and cost levels for "per head of cattle" control methods such as trypanocides and pourons);
- human population density at the start of the programme (influencing fly habitat and also helping determine benefit units, for example the potential for using draught power);
- for each area the cost of once-off tsetse clearance plus the ongoing cost of barriers, weighted by the risk of needing to retreat the area;
- the cost of the technically feasible ongoing tsetse suppression techniques.

These thresholds can be defined with some accuracy for a particular area or region with similar areas - but as everyone who has worked on the tsetse and trypanosomiasis problem knows, generalizing is very difficult. There are other criteria to be included, in particular human and livestock population pressure in neighbouring areas. It should be noted at this stage that on the benefit side these thresholds are, to all intents and purposes, the same ones that are used in the GIS filtering process in order to identify promising areas for intervention (e.g. Gilbert *et al.*, 2001; Hendrickx, 2001; Hendrickx *et al.*, 1999; PAAT, in prep.).

To complete this filtering process, benefit - cost analysis adds the possibility of summarizing much of this information in a single measure. The most practical for the purposes of this analysis is the benefit - cost ratio (BCR),[2] which is expressed as:

$$\frac{\text{sum of all discounted benefits over the time span considered}}{\text{sum of all discounted costs over the time span considered}}$$

Benefit-cost ratios have the added advantage that they can easily be adjusted from the above measure, which calculates the return on all monies invested, to measures that analyse the return to different groups such as farmers, livestock keepers or to investment, research, etc.

The following sections discuss how the information above can be treated to produce realistic and consistent estimates on the impact of the disease over time and in response to various interventions.

PARTIAL ANALYSIS - DEFINING THE "WITH" AND "WITHOUT" SCENARIOS

The basic tool used in farm management in order to quantify the costs and benefits of a proposed modification to the production system is partial analysis, which is also sometimes called partial budgeting. It provides a useful framework for categorizing benefits and costs, and when the framework is completed it acts as a checklist, which applies particularly well to disease-control interventions (e.g. Putt *et al*, 1987; Dijkhuizen and Morris, 1997; Rushton, Thornton and Otte, 1999).

For trypanosomiasis the main items to be included under the four headings that comprise the partial analysis framework are shown in Table 1.

"With" and "without" project scenarios for benefits

Determining what the "with" and "without" project scenarios are is always difficult. On the benefits side, in terms of livestock productivity, it depends on studying before and after, or with disease and without disease situations, and should thus follow the same principles as an intervention trial in epidemiology. Swallow (PAAT, 2000), in his review paper, discusses the basis on which the production parameters with and without the disease were estimated in the various studies, distinguishing between the following approaches:

- longitudinal monitoring of herds, comparing parameters for individuals detected parasitaemic and those not detected parasitaemic;
- monitoring the health and productivity of cattle herds in similar areas distinguished by different levels of trypanosomiasis risk or challenge;
- monitoring livestock before and after control measures were undertaken.

TABLE 1
Partial analysis for tsetse and trypanosomiasis interventions

Costs	**Benefits**
a) Extra costs	*c) Extra revenue*
Extra cost of implementing the proposed intervention: • chemo-prophylaxis • use of pour-ons • traps and targets • ground-spraying, SAT, SIT, other forms of	Output from herd "with" intervention in place minus output from herd "without" intervention (output to include herd growth, animal traction and if possible a value for manure as well as milk and meat).

vector control. Extra costs associated with an increase in livestock production (more animals) and productivity.	
b) Revenue foregone	*d) Costs saved*
Negative side-effects of the chosen control strategy on land use, environment, and development of drug resistance (these are mostly difficult to quantify). Loss or reduction in a particular category of output, e.g. lowered rural meat consumption due to a reduction in emergency slaughter following from improved herd health.	Saving in trypanocide costs due to implementation of vector control options. Saving in cost of curative trypanocides if a successful preventive trypanocide regime is established.
Total costs	**Total benefits**

An analysis of these studies and discussion of the parameters obtained is outside the scope of this paper, however it will be important (see Chapter 5) to consider these issues when making recommendations on how to standardize the collection of data required for the economic analyses.

The importance of correctly assessing the "with" and "without" scenarios can be illustrated by following the series of graphs given in Figure 2. Taking the size of the cattle population as an indicator of benefit levels, Figure 2a shows the "null hypothesis" situation, i.e. that the cattle population would remain unchanged in the absence of interventions to control the tsetse and trypanosomiasis problem. This "no change" scenario is often unconsciously adopted in evaluations, forgetting that while the population *growth rate* might remain more or less the same for some years in the absence of interventions, the population itself is unlikely to be static.

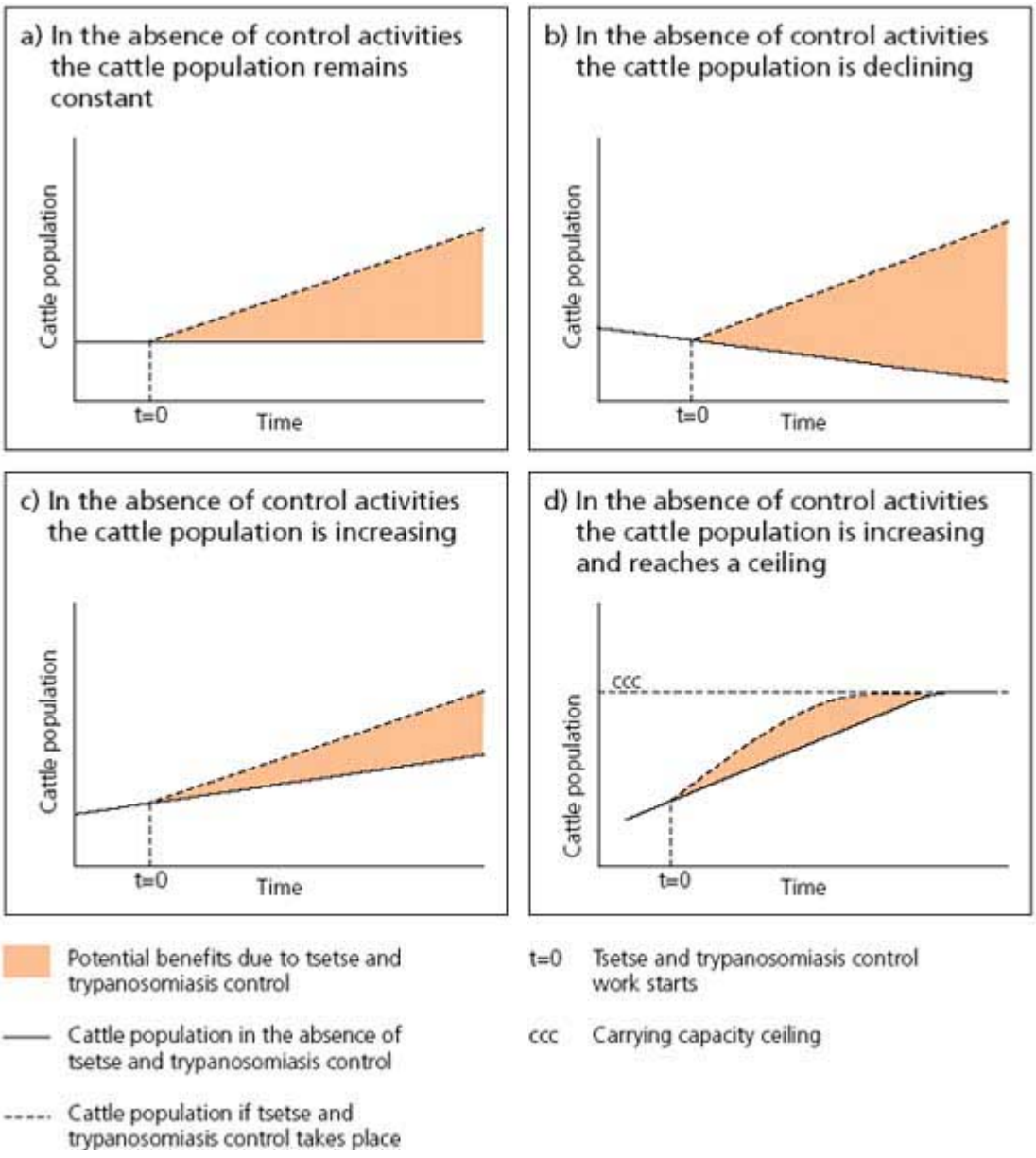


FIGURE 2
Alternative "with" and "without" intervention scenarios for tsetse and trypanosomiasis control

Figure 2b illustrates the situation where interventions to control the disease yield the highest profits - where a population is declining in the absence of control, owing to the severity of the disease - but would increase if effective control measures were implemented. This was the case, for example, in the Yalé area of Burkina Faso (Kamuanga *et al.*, 2001a) where there had been massive losses due to the disease, reflected in a huge decline in the population.

Figure 2c, however, illustrates a situation that is often encountered in West Africa's moist savannah zone, where even in the absence of interventions to control tsetse and trypanosomiasis,

the cattle herds are still growing. This has been the situation in Côte d'Ivoire, due perhaps to farmers' use of trypanocides and to the presence of trypanotolerant cattle (Camus, 1981; Shaw, 1993; Pokou, Swallow and Kamuanga, 1998). A similar situation is found in parts of northern Nigeria (Shaw, 1986). In this situation, potential benefits are lower than under the previous scenarios.

Finally, Figure 2d can be seen as an extension of Figure 2c, showing what the situation would be if there were a production ceiling, usually imposed by an area's livestock carrying capacity limit, itself determined both by the quality of the natural forage and by the proportion of land taken up for farming. In this case, production under the "with" and "without" scenarios converges and the effect of disease control is to enable production from cattle to reach its ceiling earlier on. Benefits under this scenario, although lower than under the others, may still be significant.

An issue which further complicates assessments of the impact of tsetse control strategies, is the possibility of using pour-on preparations that also affect ticks, and thus produce a wider range of benefits whose impact is difficult to compare to those of other tsetse and trypanosomiasis control strategies.

This discussion has not directly mentioned the issue of cattle migration, and more specifically immigration into areas that have been cleared of tsetse. A method for dealing with this issue, which seems to work well, is to take the cattle population affected by the project as being:

- those animals present in the area at the start of the project,
- plus any animals that migrate into the area during the course of the evaluation period,

and assume that both groups benefit from improved productivity, since the immigrants presumably moved into the area because they hoped for better conditions - whether better grazing or less risk from disease. This approach produces realistic results for actual situations and can be integrated into a herd model (Putt *et al.*, 1989; Shaw, 1990, 1993).

"With" and "without" project scenarios for costs

Identifying the "with" project costs is usually relatively straightforward, since these mainly involve direct expenditure on a new disease-control programme. However, if one of the impacts of the project is to increase livestock numbers and/or productivity, this may involve extra production costs for livestock keepers and these need to be included in the extra costs.

More difficult to assess are the "without" project costs. The main issue to consider here is "how are farmers now, and how will they continue to manage the problem of trypanosomiasis in the future?" More evidence of how they do this is slowly accumulating. CIRDES, ILRI and ITC (2000) comment on farmers' expertise in "integrated disease management" and state "The strategies that livestock owners adopt for production under trypanosomiasis risk have elements that take effect over the long-term, medium-term and short-term. Choices with long-term effects, especially regarding livestock breed and type, condition choices with medium-term effects, especially regarding transhumance and use of acaricides for tsetse and tick control. Similarly, choices with long-term and medium-term effects condition choices with short-term effects,

especially the use of trypanocidal drugs." Looking at the RTTCP countries, Van den Bossche and Vale (2000) discuss the widespread use of trypanocides, and state that "preference is given to the treatment of oxen and cows, i.e. the productive animals in the herd" and Doran (2000) points out that in the surveys conducted, trypanosomiasis challenge seems to affect calving rates, but not cattle mortality rates which may be masked by the effects of curative treatment. This tendency to prioritize on cows and oxen is very sound in economic terms. Looking at the economics of traditional cattle-production systems in West Africa, most of the output by value either consists of milk and draught power or is linked to herd growth. These in turn are a function of the health of adult females and draught oxen. Thus, taking a herd model and simulating the results of removing the effects of the disease in these two groups of animals deals with around 75 percent of the losses due to trypanosomiasis in many situations.

TABLE 2
Partial analysis for tsetse control in an area where farmers currently use trypanocides

Costs	**Benefits**
a) Extra costs	*c) Extra revenue*
Cost of the tsetse control strategy implemented. Extra costs for rearing more animals.	Output from herd under tsetse control minus output from that herd if the current use of trypanocides had continued.
b) Revenue foregone	*d) Costs saved*
As noted in Table 1, but difficult to quantify.	Saving in trypanocide costs due to implementation of vector control options. Reduced risk of drug resistance.
Total costs	**Total benefits**

Thus, taking into account "with" and "without" project scenarios in this way means that the relevant partial analysis framework for the introduction of tsetse control would be as given in Table 2.

In Table 2, the benefits under c) would be the added increase in output due to a switch from using drugs to tsetse control and under d) for the savings that livestock keepers would now be able to make on trypanocides. In this context, Pokou, Swallow and Kamuanga (1998) and CIRDES, ILRI and ITC (2000) did note that farmers in northern Côte d'Ivoire continued to use drugs in the tsetse suppression area, probably partly because they were not completely aware of the extent to which tsetse control has reduced risk, and partly because some isk was actually still present and animals were being sent outside the tsetse control area on seasonal transhumance. Other factors might be the usefulness of these drugs against babesiosis, and the fact that in many places, trypanocides are still among the few veterinary drugs which are widely available.

OTHER METHODOLOGICAL ISSUES

There are a number of other methodological issues in project analysis, which have relevance to the analysis of the tsetse and trypanosomiasis problem.

The distinction between financial and economic analyses should briefly be mentioned (see Gittinger, 1982 for a detailed discussion). This operates at two levels.

a) The viewpoint from which the analysis is made - an economic analysis usually embraces the benefits and costs to society as a whole, while a financial analysis tends more often to be undertaken looking at the costs and benefits to individuals, specific groups or organizations (e.g. crop farmers, livestock keepers, cattle traders, governments).

b) The prices used in the analysis - there is a convention of using "accounting" or "shadow" prices which attempt to adjust market prices so that they better reflect real resource costs; this is particularly the case for some prices such as foreign exchange rates, or agricultural prices that are fixed by government, accounting prices have been used in looking at tsetse and trypanosomiasis control economics, for example by Jahnke (1974) and Itty (1992).

In practice, many economists end up producing a sort of "halfway house" midway between an economic analysis and a financial analysis, by making adjustments for over-valued exchange rates and taxes and subsidies while leaving most other prices at their current market values. The term "economic" tends to be used as the general term covering both approaches, and this convention is followed here. Most of the analyses conducted here are economic in the sense that they look at the benefits and costs to society rather than individual groupings, and financial in the sense that they are based on current market prices. However, as discussed at the start of Chapter 3, a number of studies have looked at the benefits and costs from the financial viewpoint of farmers and livestock keepers (Blanc, Le Gall and Cuisance, 1995; Woudyalew *et al.*, 1999; McDermott, Coleman and Randolph, 2003). In addition, a number of studies have examined farmers' willingness to pay for tsetse control, these were studied for a West African situation by Kamuanga *et al.* (2001b) and the various studies were reviewed by Kamuanga in PAAT (2003).

Dealing with risk and uncertainty is obviously crucial when looking at the possible outcomes and costs of tsetse and trypanosomiasis control. Sensitivity analyses are an effective way to deal with this, by studying the effects of changes in key assumptions and seeing how sensitive the project's performance is to likely changes. As mentioned above, identifying the threshold at which a project becomes profitable, through some form of break-even analysis is another way of defining the project's limits (e.g. with respect to disease incidence in the absence of control or minimum human and cattle populations necessary to generate sufficient benefits to make the project economically feasible).

The time horizon selected is also important, especially when comparing control and eradication options, as mentioned above in the section on "Time value of money", page 11. The figure conventionally selected in benefit - cost analyses is 20 years and this has been used in the model runs below. Sensitivity analyses looking at 30 and 40 years are desirable, particularly if eradication is being considered - however, these need to be very carefully interpreted, since looking that far ahead into the future involves considerable speculation, and the assumption that current trends will continue can be enormously misleading.

DEFINING THE PROJECT TO BE ANALYSED

Finally, against the background of discussions on huge area-wide programmes to eliminate the fly over large sections of the continent, what is the rationale for trying to prioritize and select intervention programmes to control the tsetse and trypanosomiasis problem? The terms of reference for this paper were to produce guidelines for prioritizing intervention programmes on the basis of economic criteria. In economics, decisions are made at the margin, that is by comparing the potential additional benefit from a proposed change to the likely additional costs as shown in the framework for partial analysis (see Tables 1 and 2). In looking at the tsetse and trypanosomiasis problem, it is essential that individual projects are defined, analysed and ranked using each of the SITE criteria (see beginning of Chapter 3). The size of such projects should take into account the following.

- The project must be technically feasible - the area must have a defined trypanosomiasis problem, be of a suitable size for the most cost-effective control technique (such as a fourth-level river basin for area-wide tsetse eradication, see Hendrickx, 2001; PAAT, in prep.) or the zone should be covered by a defined group capable of concerted action (such as farmers with a particular problem and outlook, a development project or an administrative or extension structure).
- Funding for the project must exist - there is no point in analysing a project for which funds will run out half way through, since this will prejudice the outcome and render the initial appraisal invalid.
- The technical capacity to carry out the project must exist.

Thus, it is strongly argued that each individual project, of whatever size, needs to be assessed on its own merits, not, especially at this stage, for its contribution to a continent-wide super-programme. The issue of timing, in particular, is important here. It is recognized that, as stated by the PAAT Advisory Group at its 8th meeting in 2002, while we "resolve to reduce and ultimately eliminate the constraint of tsetse-transmitted trypanosomiasis in man and animals ... progress towards the final objective is best achieved through concerted efforts towards intervention in a sequential fashion, with the focus on those areas where the disease impact is most severe and where control provides the greatest benefits to human health, well-being and sustainable agriculture and rural development". It follows that undertaking tsetse eradication work on the fringes of the tsetse distribution, where the tsetse habitat is already marginal, cannot be justified purely in order to accrue benefits which will only start very far in the future and in another part of the continent. However, as Chapter 4 shows, it is in some of these fringe areas in West Africa, that controlling trypanosomiasis in cattle does yield high benefits.

Farm management

Farm management, making and implementing of the decisions involved in organizing and operating a farm for maximum production and profit.

THE VALUATION OF ECONOMIC COSTS AND BENEFITS

General Considerations

After the costs and benefits of a project have been identified and the size of their flows over the life of the project established, they should be valued so that they can be aggregated and compared. The costs and benefits should be valued according to their economic prices, which in many cases will differ from their market prices.

Since the main objective of economic analysis is to assess the real contribution that a particular project is expected to make to the national economy, costs and benefits should be valued in constant prices, i.e., in terms of the prices prevailing in the year in which the project is appraised. Any expected change in the general price level during the life of the project should be disregarded, but anticipated changes in relative prices (e.g., a greater increase in the price of oil than in other products) must ˜e taken into consideration since relative price variations reflect changes in the claims on real resources of the country. 38. Financial and economic profitability will coincide if market prices are equal to the marginal social cost of production (the supply price) and the marginal social value (the demand price) of all inputs and outputs. Decisions made on the basis of these prices ensure the most efficient allocation of resources. However, market prices do not always reflect social costs or sod:il values because of a variety of market imperfections, taxes, subsidies and other interventions.
For purposes of cost-benefit analysis, discrepancies between market prices and social costs or values should be taken as given, and policies that cause these discrepancies must be assumed as remaining effective. However, if there is evidence that these policies are likely to change, these changes should be taken into account.

Economic analysis of projects requires estimates of the marginal social cost or value of the inputs used and the outputs produced by a project. The following paragraphs suggest an approach for such valuation of costs and benefits. Special attention is given to the valuation of traded as well as nontraded commodities, the valuation of the services of labor, and the use of conversion factors for establishing correct relationships between the prices of traded and non -traded goods for purposes of estimating the rate of return of a project.

Economic Prices of Traded Goods and Services

It is necessary to make an initial distinction between goods and services traded internationally at the margin and those that are not. These are respectively referred to as "traded" and "non-traded" goods and services. The term “traded” means that the goods and services concerned are actually imported into or exported from the country, and is not subject to binding quantitative restrictions such as import quotas or to prohibitive trade taxes (i.e., taxes that are so high as to prevent trade from occurring). All other goods and services are "non-traded". The valuation of these two categories of goods and services is different.

In the case of traded goods it can usually be assumed that the country concerned can buy and sell such goods at prevailing prices. In this case, traded goods and services are valued at their "border prices," i.e., net of any trade taxes or subsidies. These are the CIF prices in the case of imports and the FOB prices in the case of exports. The prices are calculated by using the official exchange rate and then are adjusted for local transport and distribution costs, though trade taxes or subsidies are not included in the prices used in economic analysis of projects.

Production or use of traded goods by a project generally does not affect border prices since the impact on global demand and supply may well be small. However, in cases where such an assumption is not justified and project inputs or outputs are likely to influence border prices, the marginal costs of the inputs or marginal revenues from the output should be used in valuing traded commodities. Changes in prices due to a project also affect the demand and supply of goods and services elsewhere in the economy. The effects of these changes in addition to their effect on foreign trade must also be taken into account in evaluating a project.

Economic Prices of Non-Traded Goods and Services

The valuation of non-traded goods and services tends to be more complex than the valuation of traded goods and services because production or use of non-traded goods in a project often affects domestic market prices of

these and hence the use or production of these goods by other users or producers. The use of non-traded goods as project inputs may be met partly by reducing domestic consumption of these goods and partly by increasing domestic production. If the use of a non-traded input by the project affects only the amount of use by others, the input's economic price should be derived from its marginal value to users (its demand price). If the project affects only the level of production, then the economic cost should be derived from the input's marginal cost of production (its supply price). If the project affects both production of the input and use by others, then the economic price of the input should be derived from the weighted average of the demand and supply prices, using the shares of production and use by others as weights.

In most cases, the supply price or cost of production is used in the valuation of non-traded goods and services. However, it should be noted that there are several cases in which the price of non-traded goods and services departs significantly from its marginal cost. For example, peak load power or power supply to rural areas may be priced well below marginal cost, railway tariffs may not fully reflect the transportation costs of goods either by commodity type or by destination, and road transport rates may not reflect the costs of highway development and maintenance. It is necessary that such discrepancies between price and marginal cost be taken into account in the valuation of non-traded goods and services.

D. Shadow Wage Rate

Among non-traded goods and services, labor is the single most important component. Hence, an appropriate procedure for the valuation of labor is important for economic analysis of projects. Since the objective is the maximization of net output or income, the extent to which labor use affects project costs or results in loss of output elsewhere in the economy must be assessed.

Project accounts are determined on the basis of prevailing market wage rates for the various categories of labor. In general, the market wage for a particular category of labor determines the level of employment for that category of labor. If the prevailing market wage is higher than the supply price of a particular category of labor, then there will be some unemployment for that type of labor. In such a situation, the additional demand for labor for the project will be met, at least partly, by a reduction in unemployment and, to that extent, there will be no loss in output elsewhere in the economy. Hence the appropriate valuation for such unemployed labor will be the supply price which, by assumption, will be lower than the market wage rate.

The additional demand for labor in one sector may be met by workers from another sector. Analysis of the impact of additional labor demand through interlinked labor markets is required to identify sectors in which the adjustments will take place. The existence or absence of surplus labor in these sectors determines the nature of adjustments to labor costs required for economic analysis.

Even in countries with high rates of unemployment or underemployment, it is unrealistic to assume that labor is available at a wage close to zero, since at a very low wage, many people prefer leisure to employment. The supply price of labor depends on several factors including household income, the value placed on leisure and other non-wage activities, and the nature of employment vis-a-vis income and other benefits accruing from employment. Thus, it would be simplistic analysis to ignore the supply price altogether in estimating the economic price of labor, and it is reasonable to assume that the shadow wage rate is considerably higher than that indicated by narrow application of the opportunity cost principle.

Although labor is of many types and grades, for purposes of analysis, labor required for a project may be divided into the three categories of skilled, semi-skilled and unskilled. Since the level of remuneration for the three types varies, each category of labor should be treated separately when establishing shadow prices.

The market for skilled labor is generally competitive and such skills are often in short supply. The market wage for such workers should therefore be assumed to be the value of output forgone at market prices for this type of labor. The market wage should include, in addition to the basic wage, allowances, social security contributions and other benefits.

Semi-skilled and unskilled labor is employed in both the formal, or "protected" sector, where wages are regulated by the government, and in the informal, or "unprotected" sector, where regulations do not apply. The supply price of labor in these two categories is assumed to be equal to the market wage rate in the informal or "unprotected" sector, the reason being that even if a new job created by a project is filled directly by a worker drawn from the formal sector - which means he is paid at the market wage rate - the vacancy created in the formal sector will be filled by a worker, employed or unemployed, from the informal sector. The net loss of output for the society is thus the marginal product of a worker in the informal sector, i.e., the informal sector wage.

The supply of semi-skilled labor relative to demand is likely to vary from country to country. If there is a clear evidence of oversupply, then the "unprotected" wage should be adjusted downward, taking into account the extent of unemployment in the relevant skills, but not below the "unprotected" wage for the unskilled labor, since the semi-skilled workers have a competitive edge over unskilled workers in finding unskilled jobs.

With regard to unskilled labor, many developing countries have high levels of unemployment or underemployment in both urban and rural areas. In determining the value of unskilled labor in such cases, the "unprotected" wage should be the starting point. Adjustments should then be made to account for the extent of unemployment or underemployment in the country, particularly in the project area, at the same time taking into account the "reservation" wage below which people in the area may be unwilling to offer their labor as wage-earners.

The economic price of labor in urban areas is likely to be higher than in rural areas and also to vary from region to region. Such differences arise in part because labor must be compensated for migrating from one place to another. In determining the economic price of labor, both the level of skills required and the location of the project should be taken into account.

Conversion Factors

The previous sections of this chapter have dealt with the valuation of traded and non-traded commodities and labor. According to the procedure suggested, traded goods should be valued in terms of border prices, and nontraded goods and labor in terms of opportunity costs valued in domestic prices. There remains the task of bringing the two sets of prices into correct alignment. Two approaches are possible in this regard. The first is the shadow exchange rate approach, which converts the border prices of traded inputs and outputs into their domestic price equivalents. The second is the conversion factor approach, which is used to convert the domestic prices of non-traded goods and labor into their border price equivalents. The advantage of the conversion factor approach is that it takes into account distortions in the pricing of nontraded inputs and outputs that are specific to the project. Since in Bank projects most of the outputs and a large proportion of inputs are traded, the use of conversion. factors yields more reliable results than the alternative approach.

It may be noted that the shadow exchange rate and the conversion factors are not meant to reflect balance of payments disequilibria; they only reflect differences between border prices and domestic market prices which may be present even when the balance of payments is in equilibrium.

The non-traded inputs used or produced by a project have an'impact on production and consumption. The conversion of the domestic prices of nontraded goods into equivalent border prices can be based on an analysis of this impact. Conversion factors are defined for specific commodities or groups of commodities and provide a means of estimating border prices which is founded on such an analysis.

Generally, the non-traded inputs required by a project will be met by increased production, in which case the appropriate valuation will be the supply price. The conversion factor for converting this supply price into the equivalent border price is the "supply price conversion factor" (SPCF). When a project produces a non-traded output, the impact will generally take the form of increased consumption of the non -traded output. In such a case, the appropriate valuation is the demand-price, i.e., the price that consumers are willing to pay.
The conversion factor for converting this demand price into the equivalent border price is the "demand price conversion factor" (DPCF). When the project affects both production and consumption of the non-traded good,

weighted average of the SPCF and DPCF should be used, the weights being the shares of production and consumption in the total output due to the project.

The supply price conversion factor incorporates all of the adjustments required to ensure that (i) domestically produced goods are valued at marginal social cost, and (ii) that this marginal social cost is estimated at appropriate shadow prices for inputs. The first step in estimating the SPCF is analysis of the costs of production of the commodity concerned. These costs involve both traded and non-traded inputs. The traded inputs can be directly valued at border prices, labor at the shadow wage rate, and the non-traded inputs decomposed and analyzed in terms of their costs of production. In most cases, no more than three rounds of decomposition of the non-traded inputs is required to arrive at an acceptable approximation.

Demand price conversion factors are to be used whenever a project leads to a change in domestic consumption; this is generally the case in the valuation of non-traded outputs. The demand price, or the price that consumers are willing to pay, is related to the prices and quantities of substitutes and complements consumed. Changes in the quantities of substitutes and complements consumed should thus be determined and their amounts valued at border prices. The demand price conversion factor is an approximation that incorporates this correction.
For instance, in the case of a power project, electricity output may replace petroleum products or coal, which are close substitutes. In the case of a railway project, the output replaced may be road transport. A demand price conversion factor reflects the value of a non-traded output in terms of the border prices of the commodities it replaces.

When evaluating the benefits and costs of a project, it is sometimes convenient or necessary to use data that aggregates project inputs or outputs into groups such as the "costs of domestic machinery", "civil construction", "transport and distribution margins" or, for the shadow wage calculation, "the value of agricultural output forgone". In such cases, group conversion factors (GCF) may be used.

Group conversion factors are defined as weighted averages of individual commodity conversion factors for a set of commodities. For instance, the group conversion factor for civil construction may be a weighted average of the conversion factors for steel, cement, bricks, skilled and unskilled labor. Group conversion factors are approximations and may be calculated for general use for any magnitude on the benefit or cost side when the analysis in terms of specific commodities is difficult or time-consuming. Calculation of group conversion factors requires (i) an estimate of the conversion factors for the component commodities, and (ii) a set of weights for aggregation. Foreign trade and border tax data and similar sources can provide information for the estimation of conversion factors for component commodities, and data for the weights can be obtained from general statistical sources such as consumer expenditure surveys, crop production statistics, and censuses of manufacturing.

There are some items for which a group conversion factor cannot be readily estimated. In such cases, use can be made of a standard conversion factor (SCF) which is a a weighted average of the commodity conversion factors for all commodities produced or consumed in an economy.

In certain situations, commodity-specific or group conversion factors may not be available for an item. In such cases, the following procedure should be followed. First, correct any underpricing or overpricing of the critical nontraded inputs relative to marginal cost. Second, segregate the principal traded inputs used to produce the critical non-traded outputs and value them at border prices. An SCF can then be used to convert the residual non-traded element into an equivalent value in border prices. This procedure captures most of the adjustment required for the inputs.

If an SCF is used to convert the entire cost of non-traded output valued at market prices, the approach is equivalent to using a shadow exchange rate (SER). The only difference is that use of an SCF converts all values of nontraded inputs and outputs into their border price equivalents, and use of an SER expresses the values of traded inputs and outputs in terms of domestic prices. This does not affect project rankings in terms of desirability or calculations.

However, if commodity-specific conversion factors are used in making any of the adjustments, the two approaches are not equivalent, except in the unlikely event that all conversion factors are exactly equal to the SCF. The real advantage of the conversion factor approach is its more thorough treatment of nontraded inputs and outputs.

Conversion factors are basically meant to be used for converting the domestic prices of non-traded outputs into their border price equivalents. While traded goods can be valued directly in terms of border prices, since the conversion factors for non-traded outputs are derived from the conversion factors of substitute and complement goods, conversion factors for traded goods are also necessary. Conversion factors are also useful in estimating group conversion factors for both inputs and outputs. Finally, even though traded goods can be border-priced directly, it is convenient to have a complete set of conversion factors for commonly encountered project inputs and outputs.

The Social Discount Rate: A Primer for Policymakers

The social discount rate used in cost-benefit analysis (CBA) is an interest rate applied to benefits and costs that are expected to occur in the future in order to convert them into a present value. This conversion is done to ascertain what those benefits and costs are worth today. The social discount rate is widely considered to be one of the most important inputs in CBA in that small changes in this rate can result in large swings in present-value calculations, thereby having a major influence on whether a project passes or fails a cost-benefit test. However, the social discount rate is widely misunderstood for a variety of reasons. This primer explains the basic conceptual issues involved with the social discount rate and tries to clear up some common misunderstandings.

Basic Concepts

The two core discounting concepts in CBA are the "consumption rate of interest" and the "investment rate of interest." The investment rate of interest accounts for the marginal social rate of return to capital in the economy. The intuition behind this rate is that investments earn positive, compounding rates of return. The consumption rate of interest, meanwhile, represents the rate at which a unit of consumption in the present is traded for a unit of consumption in the future. This interest rate reflects consumers' time preferences and, in certain circumstances, may be represented by the risk-free market interest rate. The standard approaches to discounting in CBA all rely on these two interest rate concepts. For the sake of clarity, when this article refers to "the social discount rate" in CBA, it is the consumption rate of interest for all of society that is being referenced.

The investment rate of interest will generally be higher than observable market interest rates (and by extension the consumption rate) because the minimum required rate of return demanded by businesses will tend to exceed their costs of borrowing, owing to taxes. If the expected after-tax rate of return on a project falls below businesses' cost of borrowing, they will not undertake certain investments that might still be profitable from a societal point of view. In this way, taxes create allocative distortions in the economy that limit the amount of overall investment.

The risk-free market interest rate can deviate from the natural rate that reflects consumer time preferences, owing to factors such as inflation or market inefficiencies (e.g., externalities). Small adjustments can be made in an analysis to account for such factors. However, discounting consumption in CBA also becomes much more complicated in an intergenerational context, because while all human beings exhibit some degree of time preference, they only exhibit

positive time preference during the time they are alive. No one is impatiently waiting to be born. So while there is a potential case to be made on *positive* grounds for discounting consumption for policies that only have impacts within a lifetime or perhaps a within a generation, it does not follow that this rationale extends to policies with *intergenerational* consequences. Most often, how much value society should place on consumption in the future is an ethical question.

The Power of Compound Interest

The consumption and investment rates of interest are different from a discount rate used in financial analysis in that they are applied to real resources, which are distinct from financial resources. The consumption rate of interest is used to discount resources that are consumed, and the investment rate of interest applies to resources that are invested. Any interest rate, be it applied to money or anything else, is important owing to the power of compound interest.

Tables 1 and 2 demonstrate the influence small changes in the discount rate have on present-value calculations. As is evident from table 1, an investment paying $1 million in 100 years is worth just $72.45 in present-value terms at a 10 percent discount rate, $1,152.45 at a 7 percent rate, and $52,032.84 at a 3 percent rate.

Table 1. Present Value of $1 Million Earned 100 Years in the Future, at Various Rates of Interest

Investment rate of interest	0%	1%	3%	7%	10%
Present value	$1,000,000.00	$369,711.21	$52,032.84	$1,152.45	$72.57

Source: Author's calculations.

The primary reason for discounting cash flows is the time value of money. Since cash can be invested and earn interest, the sooner money is earned the better, otherwise interest and its subsequent returns are forgone. While the time value of money also applies to investment returns in CBA (when they come in a pecuniary form), the case for discounting nonpecuniary consumption is based on a different set of rationales than the time value of money.

On the one hand, there is the observable fact that people tend to exhibit positive time preference. That is, they prefer consumption sooner rather than later. However, as discussed earlier, this provides little justification for discounting benefits and costs to those not yet born. Common arguments for using a positive social discount rate in an intergenerational context are that people in the future will be richer than those in the present, so, owing to the phenomenon of diminishing marginal utility, a unit of consumption—including a life—can be expected to generate less utility to future citizens than to present citizens. Or sometimes it is simply stated that the well-being of people in future should be discounted at compounding exponential rates since future utility matters less than present utility.

Table 2 highlights the importance of the discounting when comparing lives saved in the future to an equivalent number of lives saved in the present. For example, 10,000 lives saved in 100 years

are worth 198 lives in the present at a 3 percent social discount rate and worth just 1 life using a 10 percent social discount rate.

Table 2. Present Value of 10,000 Lives Saved 100 Years in the Future, at Various Social Discount Rates

Social discount rate (society's consumption rate of interest)	0%	1%	3%	7%	10%
Present value (lives saved)	10,000	3,697	520	12	1

Note: Human lives are not divisible into parts. Hence, lives are rounded to nearest whole number.
Source: Author's calculations.

When to Use Each Rate

When conducting a CBA, one must be careful to use appropriate rates in their appropriate contexts. Nonpecuniary aspects of life cannot be invested in an account, so they should never be treated as if they will compound in value at the marginal rate of return to capital. At the same time, returns to capital often *can* be reinvested, so it is entirely appropriate to treat capital investments as if their returns compound in value at the investment rate.

Guidelines from the federal government conflate these two discounting concepts by recommending that regulatory agencies apply a single social discount rate to all benefits and costs, irrespective of whether those benefits and costs are like capital investments or like consumption. This is a problem because it means analysts are essentially treating all benefits and costs as if they are either consumption or investment, when rarely is this the case. Treating consumption and investment equally gives too much weight to consumption relative to a comparable amount of investment because, in general, one dollar of investment is more valuable to society than one dollar of consumption.

The way to resolve this issue is to use the two different rates in their different contexts, which means separating consumption and investment in the analysis. Positive and negative incremental investment can be kept on one side of the ledger (out of convention this is often the cost side), and consumption can be kept on the other side of the ledger (the benefits side). Then the two different interest rates can be applied distinctly to their respective benefits or costs.

Some Misconceptions about Social Discounting

Misconception #1: Analysts Are Discounting Money Rather Than Lives

Some commenters argue what is being discounting in CBA is money rather than lives saved. This confusion arises because benefits and costs are valued in monetary terms in order to compare them to one another. The undiscounted dollar values in CBA refer to monetary equivalents; i.e., the value individuals place on certain resources in terms of what they are willing to spend for them. Using such a valuation technique does not convert those resources into something that can be invested, like money. Dollars are simply a convenient measuring stick to make comparisons in value.

Consider, for example, the similar practice of adjusting the value of resources for inflation when they occur in different years (which also occurs in CBA). After an inflation adjustment, resources have a dollar value assigned to them, but those dollars actually represent bundles of real resources, hence the use of the term "real" when referring to inflation-adjusted values. Lives are not literally being converted into money when they are expressed as monetary equivalents in CBA. Real resources are ultimately what is being valued.

Misconception #2: The Opportunity Cost of Capital Is the Basis for Social Discounting

Other observers assert that a social discount rate is necessary in CBA because of the opportunity cost of capital; i.e., because capital earns a rate of return in the future. For example, government guidelines recommend regulatory agencies use a 7 percent social discount rate that "approximates the opportunity cost of capital."

Capital's rate of return cannot be the basis for social discounting, however, because the rate at which individuals discount future consumption shapes household savings patterns and by extension determines capital's rate of return. Basing the social discount rate on the opportunity cost of capital rate involves circular reasoning. Moreover, an optimum is achieved when capital investment is increased to such an extent that the investment rate of interest falls to meet the social discount rate. At this point, the additional utility generated from an incremental unit of capital investment is zero, which, again, provides no particular basis for social discounting.

Misconception #3: Only Regulatory Benefits Have Intergenerational Consequences

Social discounting often comes up in the context of climate change policy or other environmental contexts such as nuclear waste disposal, where society has to wait a long time for the benefits of a government regulation to pay off. This can create an impression that the social discount rate matters most for environmental projects or only for projects with nonpecuniary *benefits* far in the future. In fact, costs often have intergenerational consequences as well, though these costs often go unaccounted for in analysis. Even small amounts of investment displaced by government projects today can have significant long-acting consequences, owing to the power of compound interest.

Moreover, people are continually being born and dying, so what constitutes a "generation" may in fact be a relatively short period of time. While deciding how much weight to give to the consumption of future generations is based on a value judgment, a commitment to assessing the benefits and costs of policy as they actually occur requires acknowledgment of the impacts of policies through this investment channel.

A Note about Declining Discount Rates

Some economists have suggested that, owing to uncertainty, the government should consider using a social discount rate that declines over time. There are two rationales for declining discount rates that do not involve any suboptimal, or irrational, decision-making. One rationale takes the perspective of a social planner that centrally plans the economy. The discount rate of the social planner may decline over the investment horizon owing to the combination of the

social planner being risk averse and there being fluctuations in and uncertainty about the rate of economic growth in the future.

A second rationale for declining discount rates is called the Expected Net Present Value approach, and it asserts that in the presence of uncertainty, a declining discount rate is equivalent to a constant rate under certainty. Consider the possibility that there is a 50 percent chance that the social discount rate is 3 percent and a 50 percent chance that it is 7 percent. To account for this uncertainty, one could calculate the present value of the project at 3 percent, then at 7 percent, and then obtain the expected value; i.e., the average of these present values. It turns out that the implied certainty-equivalent discount rate consistent with this average present value is lower than 5 percent, the average of the two social discount rates. Furthermore, as the time horizon extends into the future, this implied discount rate gets closer and closer to 3 percent, the low end of possible discount rates. Therefore, accounting for uncertainty can entail use of a declining discount rate that is equivalent to a constant rate under certainty.

The first argument for declining discount rates, based on the preferences of a social planner, is explicitly normative. Whether to adopt this method or not is a value judgment because this rationale depends on ethical choices about the social planner's welfare function. The second argument is more compelling because it is simply a mathematical property that follows from taking the expected value of a function, although aspects of this argument are normative as well.

In either case, however, if an analyst uses a declining social discount rate owing to uncertainty, he or she must also adjust the estimation of the opportunity cost of capital over time in the analysis, since it will vary with the social discount rate. In general, a lower social discount rate means a higher estimated opportunity cost of capital and vice versa, which is why low and declining discount rates need not encourage more regulation. If the opportunity cost of capital is accounted for in analysis, regulatory costs can be very large when the social discount rate is low or declining. However, these costs often go overlooked, leading to the common view that a low social discount rate encourages more regulation.

Conclusion

This primer has sought to provide some clarity on the topic of the social discount rate and to clear up common misconceptions about this rate. Misunderstandings often stem from conflating the two main discounting concepts: the consumption and investment rates of interest. Indeed, even government guidelines on regulatory analysis seem to make, or at least encourage, such mistakes.

Moreover, some aspects of discounting are inherently normative; that is, they involve value judgments. Analysts should always be clear about what aspects of their analysis involve value judgments. For example, if the preferences of a hypothetical social planner are important determinants of present-value calculations, this fact should be made transparent in the analysis. Furthermore, the opportunity cost of capital should always be accounted for in any analysis, and analysts should understand that estimates of the opportunity cost of capital will tend to vary with the social discount rate used, rather than the other way around. Adhering to these basic principles could potentially resolve many common problems found in modern CBA.

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SCHOOL OF BUILDING & ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT – IV – COST BENEFIT ANALYSIS FOR BUILDING & INFRASTRUCTURE PROJECTS-SARA5401

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Capital Budgeting

Capital budgeting (or investment appraisal) is the process of determining the viability to long-term investments on purchase or replacement of property plant and equipment, new product line or other projects.

Capital budgeting consists of various techniques used by managers such as:

- Payback Period
- Discounted Payback Period
- Net Present Value
- Accounting Rate of Return
- Internal Rate of Return
- Profitability Index

All of the above techniques are based on the comparison of cash inflows and outflow of a project however they are substantially different in their approach.

A brief introduction to the above methods is given below:

- **Payback Period** measures the time in which the initial cash flow is returned by the project. Cash flows are not discounted. Lower payback period is preferred.
- **Net Present Value (NPV)** is equal to initial cash outflow less sum of discounted cash inflows. Higher NPV is preferred and an investment is only viable if its NPV is positive.
- **Accounting Rate of Return (ARR)** is the profitability of the project calculated as projected total net income divided by initial or average investment. Net income is not discounted.
- **Internal Rate of Return (IRR)** is the discount rate at which net present value of the project becomes zero. Higher IRR should be preferred.
- **Profitability Index (PI)** is the ratio of present value of future cash flows of a project to initial investment required for the project.

Net Present Value (NPV)

Net present value (NPV) of a project represents the change in a company's net worth/equity that would result from acceptance of the project over its life. It equals the present value of the project net cash inflows minus the initial investment outlay. It is one of the most reliable techniques used in capital budgeting because it is based on the discounted cash flow approach.

Net present value calculations require the following three inputs:

- Projected net after-tax cash flows in each period of the project.
- Initial investment outlay
- Appropriate discount rate i.e. the hurdle rate.

Net after-tax cash flows equals total cash inflow during a period, including salvage value if any, less cash outflows (including taxes) from the project during the period.

The initial investment outlay represents the total cash outflow that occurs at the inception (time 0) of the project.

The present value of net cash flows is determined at a discount rate which is reflective of the project risk. In most cases, it is appropriate to start with the weighted average cost of capital (WACC) of the company and adjust it up or down depending on the difference between the risk of the specific project and average risk of the company as a whole.

Formulas and calculation

The first step involved in the calculation of NPV is the estimation of net cash flows from the project over its life. The second step is to discount those cash flows at the hurdle rate.

The net cash flows may be even (i.e. equal cash flows in different periods) or uneven (i.e. different cash flows in different periods). When they are even, present value can be easily calculated by using the formula for present value of annuity. However, if they are uneven, we need to calculate the present value of each individual net cash inflow separately.

Once we have the total present value of all project cash flows, we subtract the initial investment on the project from the total present value of inflows to arrive at net present value.

Thus we have the following two formulas for the calculation of NPV:

When net cash flows are even, i.e. when all net cash flows are equal:

$$\text{NPV} = \text{R} \times \frac{1-(1+\text{i})^{-\text{n}}}{\text{i}} - \text{Initital Investment}$$

Where:

R is the estimated periodic net cash flow,

i is the required rate of return per period, and

n is the life of the project in months, years etc.

When net cash flows are uneven, i.e. when net cash flows vary from period to period:

$$NPV = \sum_{i=1}^{n} \frac{R_i}{(1+r)^i} - \text{Initital Investment}$$

Where:

R_i is the estimated net cash flow for i^{th} period,

r is the required rate of return per period, and

n is the life of the project in months, years etc.

These formulas ignore the effect of taxes and inflation. Read further: NPV and taxes, NPV and inflation and international capital budgeting.

Decision rule

In case of standalone projects, accept a project only if its NPV is positive, reject it if its NPV is negative and stay indifferent between accepting or rejecting if NPV is zero.

In case of mutually exclusive projects (i.e. competing projects), accept the project with higher NPV.

Examples

Example 1: Even net cash flows

Calculate the net present value of a project which requires an initial investment of $243,000 and it is expected to generate a net cash flow of $50,000 each month for 12 months. Assume that the salvage value of the project is zero. The target rate of return is 12% per annum.

Solution

We have,
Initial Investment = $243,000
Net Cash Inflow per Period = $50,000
Number of Periods = 12
Discount Rate per Period = 12% ÷ 12 = 1%

Net Present Value
$= \$50{,}000 \times (1 - (1 + 1\%)^{-12}) \div 1\% - \$243{,}000$
$= \$50{,}000 \times (1 - 1.01^{-12}) \div 0.01 - \$243{,}000$
$\approx \$50{,}000 \times (1 - 0.887449) \div 0.01 - \$243{,}000$
$\approx \$50{,}000 \times 0.112551 \div 0.01 - \$243{,}000$
$\approx \$50{,}000 \times 11.2551 - \$243{,}000$
$\approx \$562{,}754 - \$243{,}000$
$\approx \$319{,}754$

Example 2: Uneven net cash flows

An initial investment of $8,320 thousand on plant and machinery is expected to generate net cash flows of $3,411 thousand, $4,070 thousand, $5,824 thousand and $2,065 thousand at the end of first, second, third and fourth year respectively. At the end of the fourth year, the machinery will be sold for $900 thousand. Calculate the net present value of the investment if the discount rate is 18%. Round your answer to nearest thousand dollars.

Solution

PV								Factors:
Year	1	=	1	÷	(1	+	$18\%)^1 \approx$	0.8475
Year	2	=	1	÷	(1	+	$18\%)^2 \approx$	0.7182
Year	3	=	1	÷	(1	+	$18\%)^3 \approx$	0.6086

Year 4 = $1 \div (1 + 18\%)^4 \approx 0.5158$

The rest of the calculation is summarized below:

The rest of the calculation is summarized below:

Year	1	2	3	4
Net Cash Inflow	$3,411	$4,070	$5,824	$2,065
Salvage Value				900
Total Cash Inflow	$3,411	$4,070	$5,824	$2,965
× Present Value Factor	0.8475	0.7182	0.6086	0.5158
Present Value of Cash Flows	$2,890.68	$2,923.01	$3,544.67	$1,529.31
Total PV of Cash Inflows	$10,888			
− Initial Investment	− 8,320			
Net Present Value	$2,568	thousand		

Strengths and weaknesses of NPV

Strengths

Net present value accounts for time value of money which makes it a better approach than those investment appraisal techniques which do not discount future cash flows such as payback period and accounting rate of return.

Net present value is even better than some other discounted cash flow techniques such as IRR. In situations where IRR and NPV give conflicting decisions, NPV decision should be preferred.

Weaknesses

NPV is after all an estimation. It is sensitive to changes in estimates for future cash flows, salvage value and the cost of capital. NPV analysis is commonly coupled with sensitivity analysis and scenario analysis to see how the conclusion changes when there is a change in inputs.

Net present value does not take into account the size of the project. For example, say Project A requires initial investment of $4 million to generate NPV of $1 million while a competing Project B requires $2 million investment to generate an NPV of $0.8 million. If we base our decision on NPV alone, we will prefer Project A because it has higher NPV, but Project B has generated more shareholders' wealth per dollar of initial investment ($0.8 million/$2 million vs $1 million/$4 million).

Internal Rate of Return (IRR)

Internal rate of return (IRR) is the discount rate at which the net present value of an investment is zero. IRR is one of the most popular capital budgeting technique.

Companies invest in different projects to generate value and increase their shareholders wealth, which is possible only if the projects they invest in generate a return higher than the minimum rate of return required by the providers of capital (i.e. shareholders and debt-holders). The minimum required rate of return is called the hurdle rate.

IRR is a discounted cash flow (DCF) technique which means that it incorporate the time value of money. The initial outlay/investment in any project must be compensated by net cash flows which far exceed the initial investment. The higher those cash flows when compared to the initial outlay, the higher will be the IRR and the project is a promising investment.

Decision Rule

A project should only be accepted if its IRR is NOT less than the hurdle rate, the minimum required rate of return. The minimum required rate of return is based on the company's cost of capital (i.e. WACC) and is adjusted to properly reflect the risk of the project.

When comparing two or more mutually exclusive projects, the project having highest value of IRR should be accepted.

IRR Calculation

There is no direct algebraic expression in which we might plug some numbers and get the IRR.

IRR is most commonly calculated using the hit-and-trial method, linear-interpolation formula or spreadsheets and financial calculators.

Since IRR is defined as the discount rate at which NPV = 0, we can write that:

NPV = 0; or PV of future cash flows − Initial Investment = 0; or

$$\left[\frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \ldots\right] - \text{Initial Investment} = 0$$

Where,

r is the internal rate of return;

CF_1 is the period one net cash inflow;

CF_2 is the period two net cash inflow,
CF_3 is the period three net cash inflow, and so on ...

But the problem is, we cannot isolate the variable **r** (=internal rate of return) on one side of the above equation. Even though we can use the linear-interpolation formula, the simplest method is to use hit and trial as described below:

1. STEP 1: Guess the value of r and calculate the NPV of the project at that value.
2. STEP 2: If NPV is close to zero then IRR is equal to r.
3. STEP 3: If NPV is greater than 0 then increase r and jump to step 5.
4. STEP 4: If NPV is smaller than 0 then decrease r and jump to step 5.
5. STEP 5: Recalculate NPV using the new value of r and go back to step 2.

Example
Find the IRR of an investment having initial cash outflow of $213,000. The cash inflows during the first, second, third and fourth years are expected to be $65,200, $96,000, $73,100 and $55,400 respectively.

Solution
Assume that r is 10%.

NPV at 10% discount rate = $18,372

Since NPV is greater than zero we have to increase discount rate, thus NPV at 13% discount rate = $4,521

But it is still greater than zero we have to further increase the discount rate, thus NPV at 14% discount rate = $204

NPV at 15% discount rate = ($3,975)

Since NPV is fairly close to zero at 14% value of r, therefore IRR ≈ 14%

Limitations of IRR
Studies indicate that internal rate of return is one of the most popular capital budgeting tool, but theoretically net present value, a measure of absolute value added by a project, is a better indicator of a project's feasibility. This is because sometimes where the cash flows are unconventional i.e. there are net cash outflows other than the initial investment outlay, we may get multiple results for internal rate of return. This phenomenon is called multiple IRR problem. Further, internal rate of return technique assumes that all project cash flows are reinvested at the internal rate of return, which is rarely the case because new investment opportunities are seldom readily available. A variant of internal rate of return called the modified internal rate of return, attempts to mitigate this problem by calculating the internal rate of return where the net cash flows are reinvested at a rate lower than the internal rate of return itself.

NPV vs IRR

In capital budgeting, NPV and IRR conflict refers to a situation in which the NPV method ranks projects differently from the IRR method. In event of such a difference, a company should accept project(s) with higher NPV.

Net present value (NPV) and internal rate of return (IRR) are two of the most widely used investment analysis and capital budgeting techniques. They are similar in the sense that both are discounted cash flow models i.e. they incorporate the time value of money. But they also differ in their main approach and their strengths and weaknesses. NPV is an absolute measure i.e. it is the dollar amount of value added or lost by undertaking a project. IRR, on the other hand, is a relative measure i.e. it is the rate of return that a project offers over its lifespan.

Cause of NPV and IRR conflict

The underlying cause of the NPV and IRR conflict is the nature of cash flows (normal vs non-normal), nature of project (independent vs mutually-exclusive) and size of the project.

Independent projects are projects in which decision about acceptance of one project does not affect decision regarding others. Since we can accept all independent projects if they add value, NPV and IRR conflict does not arise. The company can accept all projects with positive NPV.

However, in case of mutually-exclusive projects, an NPV and IRR conflict may arise in which one project has a higher NPV but the other has higher IRR. Mutually exclusive projects are projects in which acceptance of one project excludes the others from consideration. The conflict either arises due to relative size of the project or due to the different cash flow distribution of the projects.

Since NPV is an absolute measure, it will rank a project adding more dollar value higher regardless of the initial investment required. IRR is a relative measure, and it will rank projects offering best investment return higher regardless of the total value added.

NPV: the preferred technique

Whenever an NPV and IRR conflict arises, *always accept the project with higher NPV*. It is because IRR inherently assumes that any cash flows can be reinvested at the internal rate of return. This assumption is problematic because there is no guarantee that equally profitable opportunities will be available as soon as cash flows occur. The risk of receiving cash flows and not having good enough opportunities for reinvestment is called reinvestment risk. NPV, on the other hand, does not suffer from such a problematic assumption because it assumes that reinvestment occurs at the cost of capital, which is conservative and realistic.

Example 1: Conflict due to size of a project

Project A needs $10 million investment and generates $10 million each in year 1 and year 2. It has NPV of $7.4 million at a discount rate of 10% and IRR of 61.8%.

Project B needs $1 million investment and generates $2 million in Year 1 and $1 million in Year 2. Its NPV at a discount rate of 10% and IRR turn out to be $1.6 million and 141.4% respectively.
Based on NPV one would conclude that Project A is better, but IRR offers a contradictory view. This conflict arose due to the size of the project. In the end, we should go with the NPV recommendation.

Example 2: Conflict due to unconventional cash flows

Let us consider two projects: C and D, both need $10 million investment each. Project C generates $15 million in Year 1 and $10 million in Year 2. Project D generates 0 in Year 1 and $30 million in Year 2. You can verify that Project C has NPV of $11.9 million at 10% discount rate and IRR of 100%. Project D has NPV of $14.8 million and IRR of 73.2%.

Despite both having the same initial investment, Project C has a higher NPV but Project D has a higher IRR. This is because in case of Project C more cash flows are in Year 1 resulting in longer reinvestment periods at higher reinvestment assumption and hence it has a higher IRR.

As the NPV is not skewed by the overstated reinvestment rate assumption, hence it is the preferred method.

Similarities and differences between NPV and IRR

NPV is theoretically sound because it has realistic reinvestment assumption. It considers the cost of capital and provides a dollar value estimate of value added, which is easier to understand.

Another particularly important feature of NPV analysis is its ability to notch the discount rate up and down to allow for different risk level of projects.

However, NPV is dependent on the size of the project. Without careful analysis, an investor might select a high NPV project ignoring the fact that many smaller NPV projects could be completed with the same investment resulting in higher aggregate NPV. It requires careful analysis in capital rationing.

The size of project is irrelevant for IRR. It will rank a project requiring initial investment of $1 million and generating $1 million each in Year 1 and Year 2 equal to a project generating $1 in Year 1 and Year 2 each with initial investment of $1. This feature makes it a good complement to NPV.

IRR is also easier to calculate because it does not need estimation of cost of capital or hurdle rate. It just requires the initial investment and cash flows. However, this same convenience can become a disadvantage if we accept projects without comparison to cost of capital.

However, IRR's assumption of reinvestment at IRR is unrealistic and could result in inaccurate ranking of projects. Another, quite serious weakness is the multiple IRR problem. In case of non-normal cash flows, i.e. where a project has positive cash flows followed by negative cash flows, IRR has multiple values.

What does ENPV stand for?
A model is constructed to compute the expected net present value (ENPV) without accounting for growth options.

What Is Net Present Value (NPV)?
Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyze the profitability of a projected investment or project. NPV is the result of calculations used to find today's value of a future stream of payments.

Expected NPV

Expected net present value is a capital budgeting technique which adjusts for uncertainty by calculating net present values under different scenarios and probability-weighting them to get the most likely NPV.

For example, instead of relying on a single net present value, companies calculate NPVs under a range of scenarios: say, base case, worst case and best case, estimate probability of occurrence of each scenario, and weighs the NPVs calculated according to their relative probabilities to find the expected NPV.

Expected NPV is a more reliable estimate than the traditional NPV because it considers the uncertainty inherent in projecting future scenarios.

Formula

Expected NPV is the sum of the product of NPVs under different scenarios and their relevant probabilities. The following formula is used to calculate expected NPV.

$$\text{Expected NPV} = \Sigma\ (p \times \text{Scenario NPV})$$

Scenario NPV is the NPV under a specific scenario while p stands for the probability of occurrence of each scenario.

Example
Logar Investments invests in public infrastructure projects in Afghanistan. The company is considering building a viaduct on the highway linking Kabul, the Afghan capital, with Landi Kotal, the town across the border with Pakistan. It expects to earn revenue by collecting a fee from the users of the viaduct.

You are the Corporate Finance specialist in the company and Omar Hotak, the CFO, has requested you to calculate expected NPV of the project. There are three scenarios: base case scenario assumes that the trade between Afghanistan and outside world routed through Peshawar will remain the same, the best case scenario assumes the trade will increase and worst scenario assumes the trade will decrease.

Your associate calculated the following NPVs for each scenario:

	NPV (in '000 AFN)	Probability
Best	40,000	0.4
Base	30,000	0.2
Worst	10,000	0.4

Solution

Expected NPV = Best Case NPV × Probability of Best Case Scenario + Base Case NPV × Probability of Base Case Scenario + Worst Case NPV × Probability of Worst Case Scenario

= 40,000 × 0.4 + 30,000 × 0.2 + 10,000 × 0.4 = AFN 26,000 thousand

The expected NPV of the viaduct project is 26 million Afghanis (the Afghanistan's currency).

Scenario Analysis

Scenario analysis is a what-if analysis in which a model's output is calculated for a number of scenarios. Scenario analysis is most commonly used in finance to estimate the expected value of an investment in a number of situations (such as best case scenario, base case scenario and worst case scenario).

Scenario analysis differs from sensitivity analysis in that it allows for changing more than one variables at once while sensitivity analysis measures the effect of change in one variable while keeping all other factors constant. Scenario analysis is quite similar to simulation analysis but less complex because most often it considers only the two extreme and one base case scenarios.

Steps in Conducting Scenario Analysis in Capital Budgeting

Scenario analysis of an investment would involve the following steps:

- Finding the base case output at the most likely value for each input. For example, when calculating net present value, use the most likely value for discount rate, cash flows growth, tax rate, etc.
- Finding the value of the output at the best possible value for each input. In case of calculating net present value, use the lowest possible discount rate, highest possible growth rate, lowest possible tax rate, etc. This is the best case scenario.

- Finding the value of the output at the worst possible value for each input. For a net present value calculation, it would mean the highest possible discount rate, lowest possible cash flow growth rate, highest possible tax rate, etc. This is the worst case scenario.

This gives us a range for output values. In reality, you need not work with extreme scenarios. You can easily set some variables at one extreme, others at the other extreme and some intermediate.

Example

Bolt Inc. is a company that specializes in building tracks for high speed trains in Electrasia. The company is the process of bidding for a new interstate train project. The chief bidding engineer has come up with a net present value estimate of $814.5 million. His inputs include the company's weighted average cost of capital of 8%, cash inflows of $2 billion which are expected at the end of 3rd year, annual expenditures for year 1, 2 and 3 of $300 million per year. You are the chief investment officer and CFO has asked you to conduct a scenario analysis.

Find the best case scenario and worst case scenario.

For the best case scenario, assume a WACC of 6.5%, cash inflows of $2.1 billion at the end of 2nd year and cash outflows of $400 million at the end of 1st year and $500 million at the end of second year. For the worst case scenario, assume a WACC of 9%, cash inflows of $1.2 billion at the end of 4th year and cash outflows of $200 million at the end of each year for 4 years. The initial investment is 0 in all scenarios.

For the best case scenario, the net present value (NPV_B) is $1,035 million while for the worst case scenario, the net present value (NPV_W) is $202 million.

$$NPV_B = \frac{-\$400M}{(1 + 6.5\%)^1} + \frac{\$2,100M - \$500M}{(1 + 6.5\%)^2} - 0 = \$1,035M$$

$$NPV_W = -\$200M \times \frac{1 - (1 + 9\%)^{-4}}{9\%} + \frac{\$1,200M}{(1 + 9\%)^4} - 0 = \$202M$$

From this scenario analysis, we find that the net present value of the project is expected to be between $202 million and $1,035 million with the most likely figure to be $814.5 million.

What Is the Rate of Return?

The rate of return can also be called the *return on investment (ROI)* or *internal rate of return (IRR)*. These names can mean slightly different things. As a concept, rates of return are calculated by comparing the current value of the investment with the initial cost of the investment, given as a percentage of the initial cost. The rate of return formula is as follows:

[(Current Value - Cost) / Cost] x 100 = %RR

Calculating the current value of the investment includes any income received resulting from the investment as well as any capital gains that have been realized. The rate of return is usually calculated using value created over a period of time, thus representing the net gain or loss over that time period. It's comparing two snapshots of value: the cost of the capital and the gains it has provided.

This can be a critical part of the analysis. For example, a high rate of return means something different over two years than it does over 20 years.

Applying Economic Rate of Return

The rate of return can be used to judge the success of a project. Obviously, a higher rate of return is desirable, whereas a negative rate of return represents a net loss on the investment within that specific time period.

As rate of return is usually calculated at the end of an investment's useful life, rates of different investments can be compared with each other. This information can be used to drive future investments by revealing **which types of investment provide net gain and which are unsuccessful**. A higher ROI represents a better return on the investment, but it should be taken into consideration that ROI looks at a time period without making many adjustments for the change in the value of money over time.

To understand this ERR economics concept, consider *investing* in the general sense (rather than specifics like capital projects, stocks or bonds). Having $100 today is worth more than having $100 in five years, namely because that $100 could be invested somewhere and collect interest, meaning that in five years it will in fact be worth more than $100. This assumes a generic interest rate is available for that $100 to be invested, which is often an industry standard.

Economic Rate of Return Example

Consider a company that invests $100 into three different projects. Each project ends up being worth $300 at the end of its life, meaning each project would have the same ROI. However, if project X returned $300 in two years, project Y returned $300 in five years and project Z returned $300 in 10 years, then that's a significant difference in project performance that isn't necessarily captured in the ROI. This is why businesses use the internal rate of return as well.

Return on Investment

Rate of return and *return on investment* are often used interchangeably; *internal rate of return,* or IRR, is a measure often used to gauge the **attractiveness of future investments**. IRR is designed to capture the rate where the net present value of the positive (profits, etc.) and negative (costs, etc.) cash flows reach zero. This calculation involves a *discount rate,* which is a tool investors use to judge how the value of money changes over time due to inflation and

other factors. This discount rate represents the minimum rate of return that's acceptable to the investor; most companies set a minimum discount rate, and the calculated IRR is compared to this discount rate to determine the attractiveness of the project.

The calculation of the IRR involves much iteration, so it's best to use a tool like Excel to obtain this value. The concept involves calculating over a number of time periods (for example, years) the discount rate at which the profits and losses during that time period — discounted for the future value of that time period — net to zero. This sounds confusing, so consider IRR as a number whose value is most important in comparison to other ones.

If a project has an IRR of 20% and other investments the company can make are only expected to yield 5% over the same time period, then that investment project looks favorable as opposed to the alternatives. The higher the IRR, the more potential that project has to be a good company investment as compared to other investments. This can help a company choose its types of investment strategies.

Difference between IRR and ROI

With this in mind, the difference in IRR and ROI is that ROI looks at two snapshots and does not account for the change in the value of money over time, while IRR offers an understanding of a comparable "interest rate" the investment may pay back.

IRR may seem more representative, but ROI is easily calculated and offers a straightforward capture of the value produced by the investment. IRR can be difficult to calculate, although most software like Excel offers ways to solve the iteration sum formula for the IRR.

How to Use Rates of Return

The standard rate of return or return on investment calculations can be used to **evaluate previous investments** which may have reached the end of their useful life. This lets management know which investments were worthwhile and gives them a starting point from which they can develop an understanding of *why* some investments work out and others don't.

The rate of return can also be used to **compare potential future projects**, which will require estimation of the project's lifespan, revenues to be gained over this set timeline and the potential cost of the project in capital. This is one of the values often used when management creates the capital budget for a company.

The internal rate of return is usually used against some benchmark determined by company executives as a minimum desired discount rate. Since IRR looks at the decreasing value of money over time, IRR can capture comparisons that won't appear in ROI.

Example Using Rates of Return

A company is considering two potential investments, A and B. They may have similar returns on investment, but if A is a five-year project and B is a 10-year project, that same ROI now

means two different things if you take into consideration the way the value of money changes over time. Companies that are on accelerated timetables may even require projects to break even in periods of two to three years. These analyses look at both ROI and IRR.

Use of ROI and IRR Values

Companies use these values in two different ways: **to evaluate previous investments and to make decisions about future ones**. It's easier to calculate ROI and IRR for projects that have already been completed, of course, than it is to make estimations in the future. Project managers and accounting analysts can sift through the project's costs and its revenue streams over time and provide this kind of information to management.

This is usually done at project close, but often, a company will look at investments over the last five to 10 years to evaluate which sorts of projects were the most successful. The information gained from this type of analysis becomes a part of the next step, which is making investment decisions to establish a capital budget projection for the company's future.

Making Investment Decisions

Normally, a company will have a desired value for both ROI and IRR, and the departments tasked with estimating capital costs and future returns will compare their projections to the targets in question. Investments with tangible products — new equipment, facilities, production units, improvements and so on — are often the responsibility of an engineering department that can use industry standards and best practices to estimate initial costs, ongoing costs and potential revenues.

Investments with intangible products — marketing campaigns, trainings and so on —often fall within the purview of accounting, marketing and/or sales. These departments have their own tools that can help predict future revenues as well as direct costs. The decision to invest capital in stock, bonds or other financial investments is one that is made at the executive board level.

These values are then used to determine **where to spend limited capital**. It's rare that a company has enough capital to invest in every single potential project on its list. Therefore, these values are *part of* the decision-making process. Keep in mind that there are other factors to consider when looking at potential investments.

Examples of Investment Decisions

For example, some capital projects are unavoidable — replacing old equipment or investing in new software — no matter what the ROI or IRR might be. The managers of the capital budget should be able to consider these factors to make sure that the overall rate of return stays positive.

Likewise, a project with an incredibly high IRR might come with too high of a price tag for the board of directors to approve. There are limitations in every company's resource pool.

Benefits of Certain Investments

There can also be benefits of investments that can't necessarily be seen in cash. For example, a targeted marketing campaign may also help the company's **brand image** and perception within its marketplace, which may not translate into a dollar figure but still represents intangible value to the company. Likewise, investments in research and development often don't directly affect the company's bottom line — they may, in fact, increase costs — but the value of research and development is difficult to capture directly.

Those types of investments may appear to have a poor rate of return but offer opportunities for the research and development team to explore new areas, which may lead to **new product lines** or additional improvements in the future. Another example is investment in intangible efficiency creators, like online software suites or data management programs. These types of services can improve record retention and data analysis, none of which has a direct impact financially but definitely has value within the company.

All of these factors then become a part of the decision-making process for a business. However, since a company is often driven by its financial success, values like ROI and IRR are usually significant. For any investor, it's important to understand how these numbers are calculated so that good financial choices can be made. A business's future is decided by the way investments are made in the past and present. It's critical to consider the rates of return as a big portion of the decision-making process.

Decision criteria: NPV and EIRR

The final output of the economic feasibility assessment will include the Net Present Value (NPV) of the project's economic costs and benefits. This captures the value today of the costs and benefits that occur over the life of the project. It has the benefit of summarising a lifetime of values into a single figure and allowing easy comparison of value between different projects. Comparisons of the NPVs of different projects are assessed using the same discount rate (required rate of return).

An economic internal rate of return (EIRR) is commonly also calculated, which is a similar decision factor to the financial IRR. The EIRR indicates the rate of return at which the present value of the economic costs and benefits of the project are equal. In other words, it is the discount rate for which the net present value is zero.

The EIRR should be compared with the socially required rate of return. Projects that are found to have an EIRR that is higher than the socially required rate of return would be said to be economic investments. These may then proceed for detailed analysis of their viability as PPPs.

The NPV and EIRR give different sorts of information about a project. The NPV provides a decision criterion on whether the project should proceed at all (in general a project with a negative NPV should not be pursued) and also allows direct comparison of actual value between projects. On the other hand, the EIRR is better suited to being a decision criterion only. By allowing a project to be compared against a required rate of return it gives a yes or no answer

about whether it is economic. However, the EIRR alone does not give enough information to say whether one project should be pursued ahead of another. This is a value comparison and the NPV should be used.

A note on problems that can arise with the EIRR and IRR criteria

Multiple IRRs are possible for a project whose net benefits change sign more than once over the payment stream. In this case the IRR loses its meaning. The IRR is also not the appropriate indicator for deciding between mutually exclusive projects. This is a situation in which only one of the alternatives can be chosen and once it is selected the other project is no longer possible (for example, if it is a choice between two projects that would use the same site). It is possible for one of the projects to have a higher IRR while the other project has a higher NPV. Since NPV is a measure of value (for a given rate of return) it is the appropriate decision criterion in this case. The higher NPV project should be selected over the higher IRR project.

Financial and Economic Appraisal

Financial appraisal

The essence of financial appraisal is the identification of all expenditures and revenues over the lifetime of the project, with a view to assessing the ability of a project to achieve financial sustainability and a satisfactory rate of return. The appraisal is usually done at constant market prices and in a cash flow statement format. It is the difference of all revenues and expenditures at the time at which they are incurred.

Revenues

The cash flow statement sets out the revenues to be derived from a project. These revenues can take several forms. The easiest to identify are the products and services from the project sold through normal commercial channels as well as any commercially exploitable by-products and residues. Revenue valuation is then simply a matter of estimating the sales values of these products and services.

Expenditures

The cash flow statement embraces both capital and operational expenditures. Capital expenditures are simply the expenditures of those items needed to set up or establish the project so that it can be operated. Operating expenditures are those incurred in operating and maintaining the project. Capital expenditures usually cover items related to construction of facilities, including site preparation and other civil costs; plant and equipment, comprising not only the acquisition cost but also the cost of transport, installation and testing; vehicles; and working capital. Operating expenditures typically comprise raw materials, labour and other input services, repairs and maintenance. Pre-operating expenses, sunk costs, and working capital may be included under certain conditions. In a financial appraisal used as the basis of an economic appraisal, other costs such as depreciation, interest and loan repayments are not included. Depreciation is excluded, because it would double count the capital cost. Interest payment and

loan repayment are not included, because one of the major purposes of deriving the cash flow is to determine the rate of interest the project can bear.

Some projects do not lead to any direct increase in revenues, but achieve their objective by reducing operating expenditures. When these can be quantified, they are included in the cash flow as negative operating expenditures. This can be quite straightforward with “greenfield” projects. However, where the project is instead an addition to an existing activity, then a difference between the “with” and “without” project is established. The entire output of the enterprise cannot be treated as the outcome of the project, either in terms of increased revenues or decreased operating expenditures. Only the impact of the project ought to be counted. Care must be exercised in constructing a counterfactual, for some increases in expenditures or revenues that occur after the establishment of a project would have occurred even without the project. "Before and after" is not the same as "with and without", and in project analysis it is the "with and without" comparison that matters. In cases of this kind it has proven more effective to prepare two separate cash flows, one with the new project and one without it, and then to treat the differences as the project impact.

Financial profitability

The financial profitability evaluates the returns to the financial stakeholders in the project, by calculating the rates of return to the holders of equity and therefore providing indications about improvements in the financing structure of the project. The cash flow statement describes the ability of a project to raise its own financing and to assess whether it is financially sustainable. The latter is summarised by indicators such as the financial internal rate of return (FRR), i.e. the discount rate that yields a zero net present value of the cash flow over the lifetime of the project. The FRR is then compared with the overall cost of funding rate. If the FRR falls below it, the project as defined is financially not worth undertaking, and therefore requires a redesign and/or additional sources of funding such as for instance grants and subsidies. A frequently used alternative indicator is the Net Present Value (NPV) of the project, which is calculated by using the cost of funding rate5 as discount rate. The project is financially viable if the NPV is positive. The FRR and NPV capture different aspects of the project return, but in any case lead to the same conclusions with respect to viability.

Economic appraisal

Elements for economic appraisal

Indications of financial profitability do not necessarily provide reliable estimates of the value of a project from a "social" or “European” point of view, as they focus rather on the investors' perspective. In some cases there is a coincidence of interest, making the financial appraisal a valid starting point to assess the economic viability of a project (and sometimes, financial profitability can even be valid guidance for economic profitability). In most cases, however, this is not the case, for instance when there are important spillovers or externalities. These can be costs or benefits that would arise as a direct consequence of a project, but which

accrue to agents in the economy other than those who sponsor the project or who are outside the primary market. Such indirect effects can be very important, especially when environmental or information resources such as innovation are involved, and it is clear that they should be considered when deciding whether or not to accept a project proposal. In this case, the analysis has to be broadened to include these external benefits of projects. For example, in the transport sector such economic benefits typically are: (i) the value of time saved by the users; (ii) the diminution of vehicle operating costs; (iii) the reduction in accidents; and (v) environmental benefits linked with a reduction of CO2 emissions. In contrast, economic external costs can be increased maintenance costs or any of the above-enumerated benefits if the project has a detrimental impact in their regards (e.g. CO2 emissions could increase as a result of induced traffic, higher travel speeds or a longer route). Differences between the financial and economic profitability can also be due to price distortions induced through taxes or subsidies. This may occur where inputs or outputs of the project enjoy favourably distorted prices. A project may be profitable for its sponsors because it benefits from elements of subsidies or regulated prices. This is a common situation where the project's products or inputs compete with others paying "market prices". The consequence is that either the government loses revenue or consumers have to pay higher prices than would otherwise pay, with the risk that the economy becomes a high-cost producer and cannot compete internationally.

Another case is when some payments that appear in the expenditure streams of financial analysis do not represent economic costs and are merely a transfer of the control over resources from one group in society to another group. For example, taxes and subsidies are generally transfer payments, not economic costs.6 When looking at the project from the point of view of the project entity, taxes and subsidies affect the revenues and expenditures of the project, but when looking at the project from society's viewpoint, a tax for the project entity is an income for the government and a subsidy, since the entity is an expense to the government. The flows net out. Transfer payments affect the distribution of project cash flows and hence are important to assess who gains and who loses from the project. Usually, the government collects the taxes and pays the subsidies. In these cases, the difference between the financial and the economic analyses accounts for a major portion of the fiscal impact of the project.

Some care must be exercised in identifying taxes. Not all charges levied by governments are transfer payments; some are user charges levied in exchange for goods sold or services rendered. Water charges paid to a government agency, for example, are a payment by farmers to the irrigation authority in exchange for the use of water. Whether a government levy is a payment for goods and services or a tax depends on whether the levy is directly associated with the purchase of a good or a service and accurately reflects the real resource flows associated with the use of the service. For example, irrigation charges frequently do not cover the true cost of supplying the service; thus, while they indicate a real resource flow as opposed to a pure transfer payment, the real economic cost would be better measured by estimating the long-run marginal cost of supplying the water and showing the difference as a subsidy to water users. Subsidies are

taxes in reverse and for purposes of economic analysis should be removed from the receipts of the projects. From society's point of view, subsidies are transfers that shift control over resources from the giver to the recipient, but do not represent a use of resources. The resources needed to produce an input (or import it from abroad) represent the input's true cost to society. For this reason, economic analysis uses the full cost of goods, not the subsidised price. In some cases, a project may not only increase output but also reduce the price of the output to consumers. Output price changes typically (but not only) occur in power, water, sanitation, and telecommunications projects. When a project lowers the price of the project's output, more consumers have access to the same product and the old consumers pay a lower price for the same product. Valuing the benefits at the new, lower price understates the project's contribution to society's welfare. If the benefits of the project are equated with the new quantity valued at the new price, the estimate of benefits ignores consumer surplus: the difference between what consumers are prepared to pay for a product and what they actually pay. In principle, this increase in consumer surplus should be treated as part of the benefits of the project. The benefits include the increase in consumer surplus of existing users (thanks to lower prices induced by lower costs) and the willingness to pay of new consumers net of incremental cost.

Shadow prices

Costs and benefits used in the financial analysis are valued at the prices that the project entity is expected to pay for them. Usually these are prices set by the market, although in some cases they may be controlled by government. However, these prices do not necessarily reflect economic costs to society. The economic values of both inputs and outputs may differ from their financial values because of market distortions created either by the government, the macroeconomic context or the private sector. Such distortions or market biases are government controls, over- or undervaluation of the domestic currency and imperfect market conditions, including low labour mobility and large underemployment of labour. To compensate for such distortions "shadow" prices can be calculated to reflect more closely the opportunity costs and benefits of the project. In contrast to possibly distorted market prices, shadow prices better reflect the willingness to pay and willingness to accept compensation values in the face of these market imperfections. Shadow pricing chiefly applies to:

Situations where the official exchange rate of a country does not properly reflect the scarcity value of foreign exchange. This is because the costs of imports are held artificially low (in case of overvaluation) or high (in case of undervaluation), and the demand for them is therefore arbitrarily altered. To estimate shadow exchange rates that reflect the scarcity value of foreign exchange, a recommended approach is to use conversion factors, which establish the correct relationship between the prices of internationally traded goods and services relevant to a project and the prices of goods and services that are not so traded. Distortions arise from many sources, such as import or export taxes or subsidies, quantitative restrictions on trade, and so on. Because the distortions affect different goods differently, conversion factors are, in theory, needed for each commodity involved in a project. Since this is not practical, a single conversion

factor corresponding to the economy wide shadow exchange rate, and referred to as the standard conversion factor, can be calculated. It is a summary indicator of trade distortions that are expected to prevail in the future. • In countries where the labour market functions smoothly, the wage actually paid is adequate for both financial and economic analysis. However, government interventions in some labour markets (e.g., minimum wage legislation, legal impediments to labour mobility and especially high taxes) introduce distortions that could justify using shadow wage rates to reflect the opportunity cost of using labour in a project. In this case, the monetary cost of labour is not necessarily equal to the marginal output of labour and needs to be corrected. Most commonly, in an environment where unemployment or under employment prevails, the economic cost of unskilled labour is less than the monetary cost of labour paid by the project. Reducing labour costs through shadow pricing increases the net present value of the project (social net benefits) in comparison with its financial value.

The use of shadow prices

Shadow prices can be a useful construct in assessing the value of relaxing a resource constraint for the economy. In analytical terms, the shadow price is the "Lagrange multiplier" of the constraint in the context of the optimisation problem for an objective function (e.g. social welfare) subject to a constraint (e.g. resource). The shadow price is the value of relaxing the constraint by one unit. This should be used in project appraisal when there is strong evidence for non- performing markets or when administrated prices are far away from matching supply and demand. For instance, in the case of a persistently high unemployment rate (say in excess of 10%) the excess supply of labour compared to the market clearing level means the shadow wage would be below the going wage rate. This wedge between the two values could be explained by contributions and taxes added on top of wages. To account for this in project appraisal, one can introduce the provision that the price labour input should be valued at the wage rate before taxes and social contributions, in particular in the case that a country is suffering from a high unemployment rate. Mere inspection of actual data* shows that the wedge can be a large share of labour cost, up to one-third in some countries. A practical solution to determine the shadow price for labour for project appraisal can be the reduction of unit labour costs by a percentage determined the share of contributions and taxes in labour cost. See chapter 4 for the case of pricing carbon emissions, another common externality requiring a shadow price adjustment. Bank appraisals use conversion factors available from national governments or from development agencies. The EC DG Regio Guide to CBA** includes a good summarised version of standard international practice. Consideration is currently being given to determine standard conversion factors to be used across Bank appraisals, and common methods to estimate conversion factors when no estimates are available. Whereas this would have the benefit of improving the comparability of Bank appraisals, the exercise would require addressing many markets in many countries and would need to be revised regularly.

Economic profitability

After taking into account all the costs and benefits of the project, the economic analysis has to give an indication on whether or not the project is worth undertaking. The Bank uses the economic rate of return (ERR) as benchmark, i.e. the discount rate that yields a zero net present value of the economic net benefits over the lifetime of the project. The ERR is then compared to the social discount rate (see chapter 8). If the ERR falls below the social discount rate, the project as defined is economically not justified and should therefore not be undertaken, as it would constitute a misallocation of economic resources. An ERR at or above the social discount rate is a prerequisite for the project to be financed by the Bank. The Net Present Value of the project can be calculated using the social discount rate. The project is economically justified if the NPV is positive.

Basic elements of appraisal

Appraisal may take various forms. Comparison of economic and commercial appraisal explains the main forms of economic appraisal and how it is distinguished from commercial appraisal. However, irrespective of the precise form of an appraisal, a number of basic elements are common to most of them. The following ten key steps should generally be addressed:

1. Explain the strategic context
2. Establish the need for expenditure
3. Define the objectives and constraints
4. Identify and describe the options
5. Identify and quantify the monetary costs and benefits of each option
6. Assess risks and adjust for optimism bias
7. Weigh up non-monetary costs and benefits including sustainability, equality and lifetime opportunities
8. Calculate net present values and appraise uncertainties, including appropriate sensitivity analysis
9. Assess affordability and record proposed arrangements for funding, management, marketing, procurement, benefits realisation, monitoring and post project evaluation
10. Assess the balance of advantage between the options and present the results and conclusions

INTRODUCTION TO RISK ANALYSIS IN CAPITAL BUDGETING

While discussing the capital budgeting techniques in assumed that the investment proposals do not involve any risk and cash flows of the project are known with certainty. This assumption was taken to simplify the understanding of the capital budgeting techniques. However, in practice, this assumption is not correct. Infact, investment projects are exposed to various degrees of risk. There can be three types of decision making:

A. Decision making under certainty: When cash flows are certain
B. Decision making involving risk: When cash flows involve risk and probability can be assigned.

C. Decision making under uncertainty: When the cash flows are uncertain and probability cannot be assigned.

Risk and Uncertainty

Risk is the variability in terms of actual returns comparing with the estimated returns. Most common techniques of risk measurement are Standard Deviation and Coefficient of variations. There is a thin difference between risk and uncertainty. In case of risk, probability distribution of cash flow is known. When no information is known to formulate probability distribution of cash flows, the situation is referred as uncertainty. However, these two terms are used interchangeably.

Reasons for adjustment of Risk in Capital Budgeting decisions

Main reasons for considering risk in capital budgeting decisions are as follows

1. There is an opportunity cost involved while investing in a project for the level of risk. Adjustment of risk is necessary to help make the decision as to whether the returns out of the project are proportionate with the risks borne and whether it is worth investing in the project over the other investment options available.

2. Risk adjustment is required to know the real value of the Cash Inflows. Higher risk will lead to higher risk premium and also expectation of higher return.

SOURCES OF RISK

Risk arises from different sources, depending on the type of investment being considered, as well as the circumstances and the industry in which the organisation is operating. Some of the sources of risk are as follows

1. **Project-specific risk**- Risks which are related to a particular project and affects the project's cash flows, it includes completion of the project in scheduled time, error of estimation in resources and allocation, estimation of cash flows etc. For example, a nuclear power project of a power generation company has different risks than hydel projects.

2. **Company specific risk**- Risk which arise due to company specific factors like downgrading of credit rating, changes in key managerial persons, cases for violation of intellectual property rights (IPR) and other laws and regulations, dispute with workers etc. All these factors affect the cash flows of an entity and access to funds for capital investments. For example, two banks have different exposure to default risk.

3. **Industry-specific risk**- These are the risks which effect the whole industry in which the company operates. The risks include regulatory restrictions on industry, changes in technologies etc. For example, regulatory restriction imposed on leather and breweries industries.

4. **Market risk** – The risk which arise due to market related conditions like entry of substitute, changes in demand conditions, availability and access to resources etc. For example, a thermal power project gets affected if the coal mines are unable to supply coal requirements of a thermal power company etc.

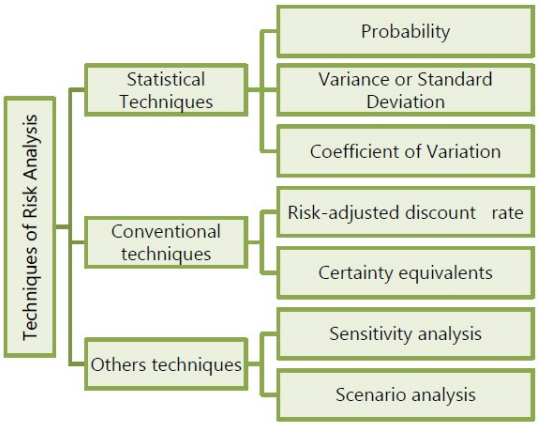
5. **Competition risk**- These are risks related with competition in the market in which a company operates. These risks are risk of entry of rival, product dynamism and change in taste and preference of consumers etc.

6. **Risk due to Economic conditions** – These are the risks which are related with macro-economic conditions like changes monetary policies by central banks, changes in fiscal policies like introduction of new taxes and cess, inflation, changes in GDP, changes in savings and net disposable income etc.

7. **International risk** – These are risk which are related with conditions which are caused by global economic conditions like restriction on free trade, restrictions on market access, recessions, bilateral agreements, political and geographical conditions etc. For example, restriction on outsourcing of jobs to overseas markets.

TECHNIQUES OF RISK ANALYSIS IN CAPITAL BUDGETING

Techniques of risk analysis in capital budgeting can be classified as below:



STATISTICAL TECHNIQUES

Probability

Meaning: Probability is a measure about the chances that an event will occur. When an event is certain to occur, probability will be 1 and when there is no chance of happening an event probability will be 0.

Variance

Meaning: Variance is a measurement of the degree of dispersion between numbers in a data set from its average. In very simple words, variance is the measurement of difference between the averages of the data set from every number of the data set. Variance is calculated as below:

$$\sigma^2 = \sum_{j=1}^{n} (NCF_J - ENCF)^2 P_j$$

$\square^2$ is variance in net cash flow, P is probability, ENCF expected net cash flow.

Variance measures the uncertainty of a value from its average. Thus, variance helps an organization to understand the level of risk it might face on investing in a project. A variance value of zero would indicate that the cash flows that would be generated over the life of the project would be same. This might happen in a case where the company has entered into a contract of providing services in return of a specific sum. A large variance indicates that there will be a large variability between the cash flows of the different years. This can happen in a case where the project being undertaken is very innovative and would require a certain time frame to market the product and enable to develop a customer base and generate revenues.

A small variance would indicate that the cash flows would be somewhat stable throughout the life of the project. This is possible in case of products which already have an established market.

Standard Deviation

Standard Deviation is a degree of variation of individual items of a set of data from its average. The square root of variance is called Standard Deviation. For Capital Budgeting decisions, Standard Deviation is used to calculate the risk associated with the estimated cash flows from the project.

The Coefficient of Variation

The standard deviation is a useful measure of calculating the risk associated with the estimated cash inflows from an Investment. However, in Capital Budgeting decisions, the management is several times faced with choosing between many investments avenues. Under such situations, it becomes difficult for the management to compare the risk associated with different projects using Standard Deviation as each project has different estimated cash flow values. In such cases, the Coefficient of Variation becomes useful.

The Coefficient of Variation calculates the risk borne for every percent of expected return. It is calculated as:

$$\text{Coefficient of variation} = \frac{\text{Standard Deviation}}{\text{Expected Return / Expected Cash Flow}}$$

The Coefficient of Variation enables the management to calculate the risk borne by the concern for every unit of estimated return from a particular investment. Simply put, the investment avenue which has a lower ratio of standard deviation to expected return will provide a better risk – return trade off. Thus, when a selection has to be made between two projects, the management would select a project which has a lower Coefficient of Variation.

CONVENTIONAL TECHNIQUES

Risk Adjusted Discount Rate

The use of risk adjusted discount rate (RADR) is based on the concept that investors demands higher returns from the risky projects. The required rate of return on any investment should include compensation for delaying consumption plus compensation for inflation equal to risk free rate of return, plus compensation for any kind of risk taken. If the risk associated with any investment project is higher than risk involved in a similar kind of project, discount rate is adjusted upward in order to compensate this additional risk borne.

$$NPV = \sum_{t=0}^{n} \frac{NCF}{(1+k)^t} - I$$

Where,
NCFt = Net cash flow
K= Risk adjusted discount rate.
I= Initial Investment
A risk adjusted discount rate is a sum of risk free rate and risk premium. The Risk Premium depends on the perception of risk by the investor of a particular investment and risk aversion of the Investor.
So Risks adjusted discount rate = Risk free rate+ Risk premium

Risk Free Rate: It is the rate of return on Investments that bear no risk. For e.g., Government securities yield a return of 6 % and bear no risk. In such case, 6 % is the risk-free rate.
Risk Premium: It is the rate of return over and above the risk-free rate, expected by the Investors as a reward for bearing extra risk. For high risk project, the risk premium will be high and for low risk projects, the risk premium would be lower.

Certainty Equivalent (CE) Method for Risk Analysis

Certainty equivalent method –Definition: As per CIMA terminology, "An approach to dealing with risk in a capital budgeting context. It involves expressing risky future cash flows in terms of the certain cashflow which would be considered, by the decision maker, as their equivalent, that

is the decision maker would be indifferent between the risky amount and the (lower) riskless amount considered to be its equivalent."
The certainty equivalent is a guaranteed return that the management would accept rather than accepting a higher but uncertain return. This approach allows the decision maker to incorporate his or her utility function into the analysis. In this approach a set of risk less cash flow is generated in place of the original cash flows.

OTHER TECHNIQUES

Sensitivity Analysis

Definition of sensitivity analysis:

As per CIMA terminology," A modeling and risk assessment procedure in which changes are made to significant variables in order to determine the effect of these changes on the planned outcome. Particular attention is thereafter paid to variables identifies as being of special significance"
Sensitivity analysis put in simple terms is a modeling technique which is used in Capital Budgeting decisions which is used to study the impact of changes in the variables on the outcome of the project. In a project, several variables like weighted average cost of capital, consumer demand, price of the product, cost price per unit etc. operate simultaneously. The changes in these variables impact the outcome of the project. It therefore becomes very difficult to assess change in which variable impacts the project outcome in a significant way. In Sensitivity Analysis, the project outcome is studied after taking into change in only one variable. The more sensitive is the NPV, the more critical is that variable. So, Sensitivity analysis is a way of finding impact in the project's NPV (or IRR) for a given change in one of the variables.

Scenario Analysis

Although sensitivity analysis is probably the most widely used risk analysis technique, it does have limitations. Therefore, we need to extend sensitivity analysis to deal with the probability distributions of the inputs. In addition, it would be useful to vary more than one variable at a time so we could see the combined effects of changes in the variables.
Scenario analysis provides answer to these situations of extensions. This analysis brings in the probabilities of changes in key variables and also allows us to change more than one variable at a time.

This analysis begins with base case or most likely set of values for the input variables. Then, go for worst case scenario (low unit sales, low sale price, high variable cost and so on) and best case scenario. Alternatively scenarios analysis is possible where some factors are changed positively and some factors are changed negatively.

So, in a nutshell Scenario analysis examines the risk of investment, to analyse the impact of alternative combinations of variables, on the project's NPV (or IRR).

Scenario Analysis Vs Sensitivity Analysis

Sensitivity analysis and Scenario analysis both help to understand the impact of the change in input variable on the outcome of the project. However, there are certain basic differences between the two.

Sensitivity analysis calculates the impact of the change of a single input variable on the outcome of the project viz., NPV or IRR. The sensitivity analysis thus enables to identify that

single critical variable that can impact the outcome in a huge way and the range of outcomes of the project given the change in the input variable.

Scenario analysis, on the other hand, is based on a scenario. The scenario may be recession or a boom wherein depending on the scenario, all input variables change. Scenario Analysis calculates the outcome of the project considering this scenario where the variables have changed simultaneously. Similarly, the outcome of the project would also be considered for the normal and recessionary situation.

The variability in the outcome under the three different scenarios would help the management to assess the risk a project carries. Higher deviation in the outcome can be assessed as higher risk and lower to medium deviation can be assessed accordingly.

Scenario analysis is far more complex than sensitivity analysis because in scenario analysis all inputs are changed simultaneously considering the situation in hand while in sensitivity analysis only one input is changed and others are kept constant.