Chapter 8

Cost-Benefit Analysis

The age of Chivalry is gone: that of sophisters, economists and calculators has succeeded.

Edmund Burke

Cost-Benefit Applications ♦ Overview of Cost-Benefit Analysis ♦ Measures of Net Social Benefit ♦ Valuing Benefits and Costs ♦ The Social Discount Rate ♦ Uncertainty and Risk ♦ Distributional Issues ♦ CBA and Other Evaluation Methods

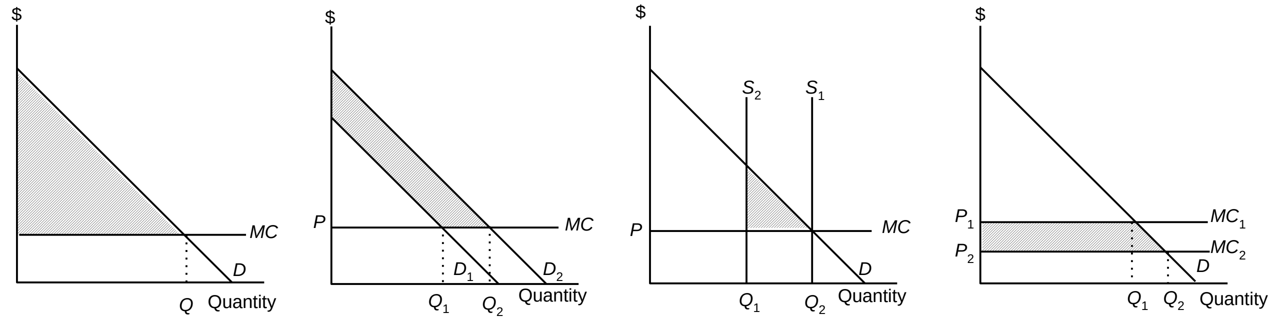
Cost–benefit analysis (CBA) aims to estimate the net social benefit (NSB) of a project or policy. The NSB equals total benefit less total cost. Benefits and costs include market and non-market goods. NSB may be positive or negative. CBA is applied to a wide range of public projects and policies, based on the principles of welfare economics. It is more comprehensive than other forms of economic evaluation, such as cost-effectiveness analysis and financial analysis. CBA is widely used across international, national and state jurisdictions.

This chapter describes the method of cost–benefit analysis. The first part describes applications and outlines the method. The chapter then describes the main features of CBA: measures of net social benefit, the valuation of costs and benefits and the treatment of time, risk and distributional issues. The last part of the chapter briefly reviews other less comprehensive evaluation methods.

Cost-Benefit Applications

CBA was developed initially to assess public capital expenditure projects, notably water and transport projects. Would the benefits justify the expenditure compared with investing in other projects?

Figure 8.1 overleaf shows various kinds of benefits that may occur with: a new good, improved service, increased capacity or lower costs. In Figure 8.1a, the benefit of a new good net of recurrent costs in a given period is represented by the shaded area between the demand curve and the marginal cost curve. The net benefit may change over time. The estimated net benefits over the life of the project are compared with the capital expenditure, which is not shown in this figure. The shaded area in Figure 8.1b shows the net benefit of an improvement in quality for some service, as demand shifts from D_1 to D_2. Figure 8.1c shows the net benefit of an increase in the capacity of a service, such as water supply, from S_1 to S_2. Figure 8.1d shows the benefit of a reduction in operating costs from MC_1 to MC_2.



(a) Net benefit of a new good (b) Net benefit of improved service (c) Net benefit of increased capacity (d) Net benefit of lower costs

Figure 8.1 Examples of benefits from capital expenditure (shaded areas)

Figure 8.1 shows the direct benefits of consumers and marginal costs of producers of the service. CBA also accounts for indirect effects where appropriate. These may be of two kinds. First, there may be impacts in related markets for complementary or substitute goods. For example, a major event may generate international visitors (the direct effects) and complementary benefits may arise for businesses servicing tourists (indirect effects). Where prices diverge from marginal costs in related markets, there may changes in producer surplus in these markets. Second, there may be indirect non-market effects, including environmental impacts, where third parties are affected (positively or adversely). Table 8.1 shows examples of direct and indirect effects in road and education projects.

Importantly, in addition to capital projects, CBA is used to evaluate recurrent programs and all kinds of policies. For example, it may be used to assess optimal class size in schools. And most regulations impose costs and confer benefits on various parties that can be assessed using CBA. For example, environmental regulations typically impose costs on firms with the aim of improved health and environmental amenity. Likewise, regulations dealing with occupational health and safety and consumer protection, for example for medicines and food, generally impose costs on firms and aim to improve individual welfare.

Table 8.1 Examples of costs and benefits in CBAs for roads and education projects

	Roads		*Education*	
	Costs	***Benefits***	***Costs***	***Benefits***
Direct effects	Construction costs Maintenance costs	Savings in travel time, vehicle costs and accidents by firms and households using new road	Public costs of providing education Student income forgone Student out-of-pocket expenses	Benefits to students (higher incomes and improved quality of life) Increase in tax returns
Indirect effects	Losses to rail operators Noise, air pollution and lower amenity around new road	Savings in travel time, vehicle costs and accidents on other roads Lower noise and improved amenity around other roads	Displacement of existing workers	Benefits to employers (higher productivity) Reductions in crime and other social costs

Australian legislation requires that all new regulations are subject to a Regulatory Impact Statement that demonstrates the net public benefit of the regulation, which in effect is a requirement to provide a CBA.

Applications of CBA can be found in many places in this book, including the evaluation of education and health care services, transport, environmental regulations and public safety policies, and in public interest tests of restrictions on competition.

Overview of Cost-Benefit Analysis

Box 8.1 provides an overview of the CBA process. The first three steps in the process are common to any rational evaluation procedure. However, some points about them should be noted as they are critical to the outcome of a CBA.

Development of appropriate options (step 2) is fundamental. This should include a 'no change' option, which is often called the Base Case. However, the easiest way to 'prove' that a project or policy is desirable is to evaluate it only against a poor Base Case and to ignore other options. The options should generally include small changes as well as large ones.

Also critical is the forecast of incremental physical impacts (step 3). These may be forecasts of traffic, power consumption, environmental impacts, health effects and so on. These effects should be estimated as incremental to the Base Case. Many forecasts are provided by other disciplines such as traffic modellers, statisticians or epidemiologists, but in some cases economic factors such as income and prices can critically affect forecast outcomes.

While it is generally desirable that economists contribute to steps 1 to 3, the key economic contributions are steps 4 to 7: valuing effects on individuals, combining them into an overall measure of project value (net social benefit) and dealing with risk and distributional issues. These contributions are discussed below. To provide a context we first describe overall measures of project worth.

Box 8.1 Key steps in cost-benefit analysis

1. Identify the issues and objectives
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2. Develop policy options, including a no-change option
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3. Identify and forecast incremental physical inputs and impacts
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4. Estimate value of these effects (costs and benefits)
↓
5. Estimate overall efficiency value of project or policy
↓
6. Test for uncertainty and risks
↓
7. Assess distributional issues
↓
8. Prepare report

Measures of Net Social Benefit

There are three main cost–benefit measures of net social benefit (NSB): the net present value, internal rate of return and benefit–cost ratio. Each measure includes all quantified costs and benefits and discounting for time differences. Each measure indicates whether the NSB is positive. If NSB is positive, a project is described as efficient—the gainers could compensate the losers so that at least one person would be better off, without making anyone else worse off. When a project passes the efficiency test by one measure, it also passes on the other two measures. However, the three tests may rank efficient projects differently.

Net present value
The present value of benefits net of costs

Net present value (NPV) is the most common efficiency measure of a project. The estimated NPV is the present value of estimated benefits net of costs:

$$\text{NPV} = \sum_{t=1}^{n} \frac{b_t - (K+c)_t}{(1+r)^t} \tag{8.1}$$

where b stands for benefits, K and c are capital and operating costs respectively, there are $t = 1...n$ years, and r is the selected discount rate (usually the rate of return on a marginal alternative project—see discussion below). If NPV > 0, the estimated total benefit exceeds total cost. Because benefits are the value of consumption gained and costs are the value of consumption forgone, a positive NPV indicates an increase in the total value of consumption. If there are several options, the one with the highest NPV would be the most efficient.

Suppose that, in constant prices, a project has a capital cost of $150 million, generates net benefits of $40 million annually for five years and the discount rate is 7 per cent per annum.

$$\text{NPV}=-\frac{150}{1.07}+\frac{40}{(1.07)^2}+\frac{40}{(1.07)^3}+\frac{40}{(1.07)^4}+\frac{40}{(1.07)^5}+\frac{40}{(1.07)^6}=\$13.1 \text{ million} \tag{8.2}$$

This project would be efficient. Indeed, if the discount rate were 10 per cent, the NPV would be $1.5 million and still be marginally efficient.[1]

Internal rate of return
The rate of return that would give a NPV equal to zero

The internal rate of return (IRR) on capital employed is the rate of return that would give NPV equal to zero. Equivalently, the IRR equates discounted net benefits to discounted capital costs. It is obtained by solving for i in (8.3):

$$\sum_{t=1}^{n} \frac{K_t}{(1+i)^t} = \sum_{t=1}^{n} \frac{(b-c)_t}{(1+i)^t} \tag{8.3}$$

where the symbols are as above except for i, which is the IRR. If the estimated project IRR exceeds the chosen discount rate (r), NPV > 0. The project is efficient. Using the same figures as in Equation 8.2, the IRR would be 10.4 per cent. The project would be efficient because the IRR exceeds the selected discount rate of 7 per cent.

$$\frac{150}{1.104}=\frac{40}{(1.104)^2}+\frac{40}{(1.104)^3}+\frac{40}{(1.104)^4}+\frac{40}{(1.104)^5}+\frac{40}{(1.104)^6} \tag{8.4}$$

However, the NPV and IRR measures may rank projects differently. Table 8.2 shows three projects, A, B and C, along with their NPV and IRR returns. Project B has a higher NPV (using a 7 per cent discount rate) than both A and C, but a lower IRR. The IRR measure favours projects with high returns in early years and small projects. However, in both cases the high IRR is misleading. Take project A—the early surpluses cannot be reinvested at the internally determined discount rate. Thus, if the $120 million surplus in year 2 were reinvested

[1] The year to which costs and benefits are discounted affects the size of NPV but not the sign. The text discounts first year costs and benefits, as the default formula for NPV in Excel does. If the analyst prefers to discount from year 2, the Excel formula can be adjusted to allow for this.

Table 8.2 Project outcomes with the IRR and NPV criteria ($m)

Project	*Year 1 Capital*	*Year 2 Net benefit*	*Year 3 Net benefit*	*IRR (%)*	*NPV 7% discount rate*
A	-100	120	0	20.0	12.1
B	-100	0	135	16.2	17.9
C	-50	0	70	18.3	10.4

at the available 7 per cent rate, the return in year 3 would be $128.4 million ($120 m × 1.07). This is less than the $135 million surplus achieved by *B* in year.

In the case of project *C*, the savings in capital expenditure cannot be invested at the same rate as that achieved by the small project. If the opportunity cost of capital is estimated correctly, the additional $50 million in capital expenditure would generate precisely $50 million in benefits (i.e. a net benefit of $0).

In general, the NPV measure provides the preferred ranking because project benefits should be discounted by the chosen rate of discount that reflects the real opportunity cost of capital rather than by an arbitrarily determined mathematical rate.

Nevertheless, the IRR can be a useful measure of project value because some people understand it more easily than the NPV. Also, it provides a check against large projects. An NPV of $12.1 million is significant for a $100 million project but not for a $1000 million project. The estimated IRR in the latter case would be only marginally above the test discount rate and a warning that this might not be a viable project.

The benefit–cost ratio (BCR) is generally defined as:

$$\text{BCR} = \sum_{t=1}^{n} \frac{(b-c)_t}{(1+r)^t} \bigg/ \sum_{t=1}^{n} \frac{K_t}{(1+r)^t} \qquad (8.5)$$

Benefit-cost ratio
The ratio of the present value of net recurrent benefits to the present value of capital expenditure

where the symbols are as above. Note that recurrent costs are placed here in the numerator.[2] If the BCR > 1, NPV > 0, and vice versa. Using the figures in Equation 8.2, and a 7 per cent discount rate, the BCR would be 1.09. This indicates that the project is just efficient.

Box 8.2 NPV versus BCR criterion

Suppose that three projects (*A*, *B* and *C*) have the following capital costs and benefits. If there were no capital constraint, *A* would be preferred. Compared with say *B*, *A* has an incremental cost of $20 million and generates incremental benefits of $35 million. On the other hand, if the agency has a capital constraint of, say, $50 million, it would maximise the surplus obtained from the $50 million by selecting *B* and *C* instead of *A*.

Project	*Capital cost ($m)*	*Discounted benefits ($m)*	*NPV ($m)*	*BCR*
A	50	105	55	2.10
B	30	70	40	2.33
C	20	50	30	2.50

2 If the purpose is to estimate the return to scarce capital expenditure, which it usually is (as in Box 8.2), only capital expenditure should be included in the denominator. However, some texts and many practitioners include recurrent costs in the denominator.

Again, the NPV and BCR measures may rank projects differently, with the BCR favouring projects with low capital expenditure. The NPV measure is generally preferred because it has no size bias. The NPV measure ensures that any additional capital required for a large project is discounted at the appropriate marginal opportunity cost of capital. If employment of additional capital increases the estimated NPV, this is the most efficient use of the capital.

However, the BCR is relevant to decision making if the capital available to an agency is constrained so that the marginal return on the agency's use of capital exceeds the marginal return obtainable elsewhere. In this case, the agency should select projects in order of their present value per unit of constrained capital (i.e. by the BCR) until the capital constraint is exhausted. This maximises the surplus (the NPV) from the use of scarce capital. Box 8.2 provides an example.

Valuing Benefits and Costs

Like any measuring system, CBA must be based on a standard unit of measure (a numeraire). The most convenient numeraire is the local currency unit in present-day domestic prices. The choice of unit does not affect the result of a CBA. Costs and benefits could also be measured in an international currency unit. What matters is the valuation principles and consistency of measurement.

We could also use forecast prices (known as current or nominal prices) instead of present-day (constant) prices. However, constant prices are simpler to use and facilitate inter-temporal comparisons. However, three implications of constant prices should be noted.

1. Use of constant prices presumes that all prices change at a similar rate, so that price relativities are constant. If the price of some good, for example electricity, is reliably forecast to change relative to the general price level, this change in real value should be allowed for.
2. Future effects should be discounted by a real rate of discount, which excludes inflation. As can be seen from Equation 8.6, the net present value of a stream of future net benefits is the same whether it is estimated with a constant price and discounted by a real rate of discount or estimated in inflated current prices and discounted by an inflated nominal discount rate:

$$\text{NPV} = \sum_{t=1}^{n} \frac{(b-K-c)_t (1+\pi)^t}{(1+r)^t (1+\pi)^t} \tag{8.6}$$

   where r is the real rate of discount and π is the rate of inflation.
3. However, a financial analysis (as distinct from a CBA) may need to allow for expected inflation. Policy makers may require forecasts of nominal cash flows, including interest payments.

The value of foreign currency can also be an issue if the exchange rate does not reflect the real value of foreign currency. This may occur because government controls the exchange rate itself or because it controls currency movements or trade. Most often, such controls result in an overvalued local currency and an undervaluation of foreign currency. In a CBA it may then be necessary to allow a premium for the real value of foreign currency. The standard approach is to adopt a price for foreign exchange based on what purchasers of foreign currency are willing to pay for it rather than the official price. This raises the effective price of imports so as to measure their social value in terms of the prices of domestic goods.

However, in the absence of government controls on the exchange rate or on international trade and capital, the market-determined exchange rate reflects the real value of foreign currency and can be used to convert foreign currency costs or earnings to the local currency value. This is the case in most OECD countries, including Australia.

Valuing goods

The general principle of valuation in CBA is that *goods (whether market or non-market goods) should be valued as the individuals concerned would themselves value them*. More precisely, adopting the compensating variation principle discussed in Chapter 6, goods would be valued at the maximum price that individuals or firms would be willing to pay (WTP) for them and be no worse off than at present.

In practice, as we saw in Chapter 6, valuations of market goods may be derived from observed or compensated demand curves (the latter hold utility constant and can provide compensating or equivalent variations). However, when income effects are small, the valuation differences arising from the different measures are small. Given the practical advantages of using observed demand curves, valuations in CBA studies are generally based on them. The points along an observed demand curve are interpreted as marginal WTP values or marginal benefits. The area under the demand curve is the total benefit.[3]

The WTP value of a good equals the sum of the price paid plus any consumer surplus. The lower the price, the larger consumer surplus likely to be. If goods are provided free, WTP is entirely consumer surplus. Estimates of consumer surplus are therefore required in many CBA studies.

When goods are marketed, standard econometric methods can be used to estimate demand curves. A critical parameter is the price elasticity of demand which shows how demand responds to changes in price. The price elasticity of demand (η_d) is the ratio of the percentage change in quantity demanded (Q_d) to the percentage change in price (P):

$$\eta_d = \frac{\Delta Q_d / Q_d}{\Delta P / P} = \frac{\Delta Q_d}{Q_d} \times \frac{P}{\Delta P} \qquad (8.7)$$

where Δ represents change. A price elasticity of –1.0 means that the percentage change in quantity demanded is inversely proportional to the percentage change in price. The price elasticity varies along linear curves and is constant for log linear curves (curves that are linear in logarithms). Price elasticities are typically estimated from time series or cross-sectional studies that relate quantities purchased to prices paid and other determinants of demand, such as income, household characteristics and the prices of other goods. In practice, most cost–benefit studies draw on established elasticities rather than estimate separate elasticities.

When goods are not marketed, other valuation methods are required. WTP amounts for non-market goods can be estimated either by other revealed preference methods or by stated preference methods. Revealed preference methods infer individual values from the behaviour of individuals in various contexts. Stated preference methods obtain values by asking people what they are willing to pay for goods. These valuation methods are described in Chapter 11, where we discuss various ways to estimate the value of non-market goods. Box 8.3 overleaf introduces the concepts by showing how they are used to estimate the value of travel time savings.

Valuing use of resources: factors of production

Resource costs are a product of the quantity of resources used and their real unit cost. Usually experts other than economists provide estimates of the quantities of resources required for production. The economist then estimates the real unit cost of these resources. Errors in cost estimates arise more often because of poor estimates of resource quantities than of unit costs.

[3] As discussed in Chapters 4 and 6, this assumes generally rational consumer behaviour.

Box 8.3 The value of travel time savings

Analysts conventionally distinguish between two kinds of travel time savings: working time and leisure time savings. Working time savings are generally valued at the wage rate of the respective tripmaker, sometimes with an addition for directly related on-costs. In a competitive market, workers are paid the value of their marginal product. If a worker earns $50 an hour, each hour spent in travel represents the loss of $50 of output and savings in travel time are worth $50 per hour. This assumes that the time spent in travel has zero productivity. Some studies have shown that this is not true. Also, the tripmaker is assumed to be personally indifferent between time spent in travel and in the office.

Leisure time savings have been valued in several ways (Hensher, 2011). Traditionally, the most common way was by revealed preference analysis of mode or route trip choices. Analysts examined how much trip makers were willing to pay to save travel time by choosing a faster but more expensive mode or route, for example travel by train rather than by bus or by a time-saving toll road rather than by a slower toll-free route. Other studies have estimated the value of travel time from house prices that vary with accessibility to employment. More recently, many analysts have used stated preference survey techniques. This may involve simply asking people what they would be willing to pay to save a certain amount of travel time or eliciting travel time values from responses to more complicated choices involving travel time, money and other travel attributes. Many studies indicate that people are willing to pay on average between 30 per cent and 40 per cent of their hourly wage to save an hour of travel time for leisure purposes. The results vary partly with the disutility of certain kinds of travel.

It may be questioned why the values of working and leisure time are not equal since microeconomic theory tells us that, at the margin, individuals forgo an hour of leisure for an hourly wage. One reason is the tax wedge. A more critical reason is that leisure time is not actually saved. If non-work travel time is saved, leisure is spent in a preferred manner—at home or in the pub rather than on a congested road. Studies of the value of leisure travel time savings are therefore valuing lifestyle preferences rather than actual leisure time savings.

Here we focus on the cost of resources (also known as factors of production). These factors include land or more generally natural resources, labour and purchases. Purchases may include purchases of materials, utility services, property and plant and equipment. Of course, purchased goods may themselves embody land, labour and capital, and other purchases.

Generally the real cost of a resource is its **opportunity cost**—this is the value of output forgone in its most productive alternative use. The key valuation principles are:

Opportunity cost
The value of output forgone by using a resource in one way rather than another

- If a resource (an input to production) is in fixed supply, its opportunity cost is the highest price that another producer would be willing to pay for it. This price would generally be the market price inclusive of any indirect taxes.
- If an input can be increased to meet project demand, its opportunity cost is the marginal cost of supply. This excludes any indirect tax and any mark-up on the costs of factors of production in an uncompetitive market. This is generally less than market price.

So when are resources or inputs to projects in fixed supply? They tend to be in fixed supply when there is full employment, natural resources or land are in fixed supply, one or a few firms control the output of intermediate goods, or government regulates the supply of the good or service. In such cases the supply of the relevant input cannot be readily expanded to meet an increase in demand. Thus the market price (the amount that another user is willing to pay for the resource) is the effective opportunity cost. In most OECD countries, including Australia, market prices are usually good indicators of the real cost of employing factors of production and of purchased inputs and few adjustments to market prices are required.

However, market prices do not represent real costs when market failures, notably imperfect competition, or government regulations cause prices to diverge from marginal cost. Thus, monopoly prices may overstate the real marginal cost of supply. Or, if there is unemployment, wages paid may not reflect the opportunity cost of employment. Where there are tariffs on imported goods, the prices of imports may not reflect their real cost. In such cases, the real opportunity cost of using a resource may vary from observed prices. In the cost–benefit literature, these real costs are often described as 'shadow prices'. This term indicates that the price does not actually exist in the market.

Let us now apply our valuation principles to the main factors of production, namely to natural resources including land, purchases of various kinds and labour.

The real cost of land and other natural resources. Given that these resources are in fixed supply, the opportunity cost (OC) of using them is their value in the highest alternative use. This applies whether the resources are privately or publicly owned. If the resource can be sold in a competitive market, its OC is the competitive market price. If land is publicly owned and cannot be sold for some reason, the cost of using it for one purpose rather than another is again its highest value in the forgone use. For example, the cost of urban parkland is typically the value of housing land than is forgone.

The real cost of purchases. Consider first purchases supplied by domestic producers. If supply is fixed, the material must be diverted from another user. The OC is the highest price that another user would be WTP for it, inclusive of any taxes. On the other hand, if the purchase can be supplied by increasing local output, the OC is the marginal cost of production exclusive of indirect taxes and subsidies and any monopoly mark-up on the price. In these cases any indirect tax or subsidy is a transfer payment and not a resource cost.

The OC principle also applies to imported goods. If there are no restrictions on imports, the cost of an imported good is simply the price paid less any tariff. The tariff is a transfer payment between importer and government and not a net cost to society. However, if there is a quota on an imported good, the supply of imports is fixed, and the cost of the imported good is its full market price.

The cost of labour. If a worker (Ben) is indifferent between occupations including leisure, the opportunity cost of employing him is the value of forgone output. If Ben would be otherwise employed in a competitive economy, the OC is his highest wage in alternative employment. If he would be otherwise unemployed, the real cost of employing him is zero. Nothing is lost by the employment. Suppose that an employer pays a wage of $120 a day, which also represents the value of Ben's marginal output in this employment. In this case the employer receives no marginal benefit. But because Ben is indifferent between work and leisure, he obtains a benefit of $120 (and society as a whole is $120 better off).

Valuation of labour is complicated when labour has occupational preferences, preferring leisure to work or working in one occupation rather than another. The real cost of employing Ben is then his 'reservation' wage—this is the minimum amount that will attract the worker into a specific employment. Suppose that Ben would require $100 a day to forgo surfing. The government offers $120 for a day's work, which he accepts. In this case the real cost of Ben's employment is $100 because this is the minimum amount that he would accept for this kind of work and be no worse off than before. Any lower figure ignores the value of his leisure.

Valuing labour at less than its nominal wage has other significant implications. Suppose that a public project costs $100 million, which includes $30 million for employing out-of-work labour who would be willing to work for $15 million. The real cost of the project is $85 million. If the project generates user benefits of $110 million, the net benefit of the project would be $25 million. This would be $110 million in user benefits plus $15 million in worker surpluses less $100 million cost to taxpayers. If the increase in employment were counted separately as a benefit of the project, the employment benefits would be counted twice.

Two further notes. First, all expenditures on factors of production, including capital expenditures, should be recorded in full when the expenditure is incurred. No interest payments are included in CBA. The discounting process captures the OC of all resources tied up in the project, whatever the source of funds. In a CBA, depreciation of capital and payments of interest on loans are not treated as expenses because this would be double counting.[4]

Second, there is an identity between WTP and OC on the one hand and consumer and producer surpluses on the other. Recall that NSB equals total benefit less total cost. Excluding externalities, for any good the benefit is the WTP amount and the cost of resources is OC. Therefore:

$$NSB = WTP - OC \tag{8.8}$$

However, consumer surplus (CS) and producer surplus (PS) equal:

$$CS = WTP - P \text{ and} \tag{8.9}$$

$$PS = P - OC \tag{8.10}$$

where P equals price. Therefore,

$$NSB = WTP - OC = CS + PS \tag{8.11}$$

This identity is useful because it is often convenient to show the net social benefit as the sum of consumer and producer surpluses.

Valuing other costs

Other costs arise may arise with negative externalities. This may raise forecasting problems regarding the impacts but does not create new valuation issues. When firms are affected, the cost is the increased cost of production or loss of output, or both.

When households experience indirect costs, such as loss of amenity or health, there may also be valuation issues associated with losses of rights discussed in Chapter 6.[5] Suffice to say here that in these cases there may be an equity argument for allowing the minimum amount that people would be *willing to accept* as compensation for the adverse impacts and be no worse off than before. However, the general practice in CBA studies is to adopt the values that individuals would be willing to pay to avoid the adverse effects.

Secondary benefits

Secondary benefits are the flow-on consequences of primary benefits. A project that generates additional income for owners of capital or for labour may create a second round of expenditure, and indeed further rounds, that raises household incomes through a multiplier effect.

Secondary benefits are not usually included in cost–benefit studies for various reasons. First, in a fully employed economy, additional expenditure cannot generate extra employment income; instead, it increases imports or displaces exports. Second, if secondary benefits occur because some resources are underemployed, secondary benefits would also arise from expenditure on an alternative project. If the secondary multiplier is M, then if for any project $B < C$, $M \times B$ is also likely to be less than $M \times C$. Thirdly, aggregate demand is a function of national monetary and fiscal policy rather than of individual projects.[6]

Of course, secondary benefits may have distributional consequences. The location of projects may advantage one region or community rather than another. These distributional effects are often of interest to government.

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4 In a financial analysis, loans may be included as income and repayments of capital and interest as expenses.

5 Of course, households ultimately bear any indirect costs borne by firms.

6 If unemployment varies by region, labour is immobile and there is no alternative project for a region, multipliers may vary and secondary benefits may be counted, but these are unusual, indeed exceptional, conditions.

Transfers

A transfer occurs when a gain to one party is offset by a loss to another. Such transfers do not affect the net social benefit of a project and so may be excluded from a CBA. However, they may also be included (as gains and losses) for completeness and transparency.

Consider, for example, changes in the government budget due to changes in tax revenues, welfare payments or subsidies. These impacts can be ignored in CBA—a dollar increase in tax revenue to government is a dollar loss to the taxpayer. The transfers affect the incidence of the benefits but do not affect resource use or net social benefit. However, for completeness it is sometimes useful to record these changes.

There are many other examples of transfers. Indeed, any pricing arrangement has transfer impacts. Certainly, the price charged for a good or service, for example a road toll or a rail fare, may affect the amount of consumption of a good, and this in turn affects the benefits and the costs in a CBA. However, the actual payment of a road toll or a rail fare is a transfer that determines the financial incidence of the benefits from a road or rail improvement.

The Social Discount Rate

The social discount rate is an inter-temporal weighting. It generally places less weight on future consumption. Following CBA valuation principles, the rate of discount of future consumption would reflect the consumption time preferences of individuals. On the other hand, the cost of capital should reflect its opportunity cost (the rate of return foregone on the marginal alternative project). Because income from capital is taxed, the gross rate of return on capital (the alternative producer rate of discount) is generally higher than the rate of return to savers (the consumer rate of discount). This difference lies at the heart of the debate about the appropriate discount rate. In addition to the consumer and producer discount rates, we also discuss below a social time preference rate of discount, a project risk-adjusted rate of discount and a synthetic (combined) discount rate.

Discount rate
The interest rate at which future income or payments are discounted to determine their present value

The consumer rate of discount, known as the private time preference rate (PTPR), is the rate at which individuals are willing to exchange marginal consumption in the present period for additional consumption in the next period. Although often described as a time preference, it may also reflect a declining marginal utility of consumption in so far as individuals expect their income to increase over time. The fact that the real rate of interest is generally positive implies that most people prefer an extra dollar of income this year to an extra dollar next year and require compensation for forgoing present consumption.

The PTPR can be calculated from market interest rates adjusted for inflation and tax. Suppose that the market interest rate (mr) for savings is 7 per cent, the marginal tax rate (t) is 30 per cent and the expected inflation rate (π) is 2 per cent. The PTPR is:

$$PTPR = \frac{1 + mr\,(1-t)}{1+\pi} = \frac{1+(0.07\times 0.7)}{1.02} = 1.028 = 2.8\% \tag{8.13}$$

A PTPR of 2.8 per cent means that, in constant prices, individuals place equal value on \$100 of marginal consumption this year and \$102.80 of marginal consumption next year.

The social time preference rate (STPR) is a variant on the PTPR, which attempts to derive temporal weights that would maximise inter-temporal social welfare rather than private welfare. It is intended, *inter alia*, to protect the interests of future generations who do not have a say on present-day interest rates or policies on climate change. Thus, the STPR is designed to equalise the marginal social utility of consumption over time. This STPR is given by:

$$STPR = \mu + (g \times e) \tag{8.14}$$

where μ is pure time impatience, g is the expected growth in per capita consumption and e is the elasticity of the marginal utility of consumption, that is, the percentage change in marginal utility associated with a 1 per cent change in consumption. There is considerable debate about whether it is appropriate to allow any value at all for pure time impatience (μ). The value of g is typically about 1.5. And, as we saw in Chapter 7, the estimated value of e is somewhere between 1.0 and 1.5 (Layard, 2008). The result is that the estimated STPR is usually a little lower than the PTPR.

The alternative producer rate of discount, traditionally described as the social opportunity cost of capital (SOC), is the marginal rate of return that can be achieved with alternative investment.[7] The SOC is generally higher than PTPR because it is measured before tax and includes the return to government, whereas PTPR is measured after tax.[8] Using the same nominal interest rate and inflation numbers as before, the SOC would be 4.9 per cent.

$$SOC = \frac{1+mr}{1+\pi} = \frac{1.07}{1.02} = 1.049 = 4.9\% \qquad (8.15)$$

The project risk-rated rate of discount is the rate of return that projects require to attract scarce risk capital to the project. This rate varies with the risk for each project.

A synthetic discount rate (SR) incorporates the SOC and PTPR as follows:

$$SR = (w \times SOC) + (1-w)(PTPR) \qquad (8.16)$$

where w is the proportion of capital employed in a project that would be invested elsewhere and $(1 - w)$ is the proportion that reflects consumption forgone.

Selecting the discount rate

Following normal valuation principles, the forecast stream of consumption benefits would be discounted by the consumer rate of discount (PTPR) or possibly by the STPR where the impacts are intergenerational. On the other hand, efficiency requires that the return on each project should be at least as high as the return on the alternative project in the private or public sector (the SOC in the terminology used here).

This dilemma can be resolved by estimating a shadow price for capital expenditure by simulating the benefit stream foregone and discounting these foregone benefits with the PTPR. This may be explained by an example. Suppose an agency plans a project costing an estimated \$100 million in year 1 and producing an estimated \$4 million of benefits each year for 30 years, with a residual value of \$100 million in year 31. Suppose also that the SOC is 5 per cent and the PTPR is 3 per cent. Would this be a viable investment?

If the SOC is 5 per cent, an alternative investment of \$100 million would provide the equivalent of \$5 million benefits per annum plus a residual value of \$100 million. Discounting this income stream by 3 per cent gives a present value of \$135.2 million. In other words, when the rate of return forgone is 5 per cent, an investment of \$100 million for 30 years is equivalent to giving up consumption with a present value of \$135.2 million. This is the real cost, or shadow price, of the capital investment. On the other hand, with a discount rate of 3 per cent, the present value of \$4 million per annum over 30 years plus \$100 million in year 31 is only \$116.1 million. As this is less than the \$135.2 million of forgone consumption, the NPV is negative and the project is not efficient.

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[7] In some recent literature, the term "social opportunity cost of capital" has been applied to the synthetic rate of discount (the cost being a weighted function of investment and consumption displaced by the project).

[8] The return on alternative investment may also include an allowance for non-diversifiable market risk.

Although technically attractive, this 'shadow price of capital' approach is rarely employed. One reason is complexity in application. Another is that applying the SOC rate of discount to all costs and benefits provides similar results. This can be illustrated as follows. Suppose that a project has a capital cost K and a perpetual stream of annual benefits b. Discounting the benefits by the PTPR (r), their present value is:

$$PV(b)_t = \sum_{t=1}^{\infty} b_t / (1+r)^t = b / r \qquad (8.17)$$

Turning to the capital cost and discounting the (perpetual) stream of benefits forgone also by the PTPR, the present value of these costs is:

$$PV(K) = (K \times \rho)/r \qquad (8.18)$$

where ρ is the SOC. Therefore, a project has a positive NPV if

$$b/r - (K \times \rho/r) > 0 \qquad (8.19)$$

Equation 8.19 implies

$$b > K \times \rho \qquad (8.20)$$

In words, if the PTPR is applied both to the benefits (consumption obtained) and the costs (consumption forgone), a positive NPV requires that annual benefits exceed the product of the capital invested and the SOC.

While this is a special case, if all capital expenditure represents forgone capital investment rather than foregone present consumption, using the SOC discount rate generally produces the same result as using a shadow price of capital along with the PTPR. Suppose again that a $100 million investment produces $4 million of benefits each year for 30 years and a residual value of $100 million. Employing a SOC discount rate of 5 per cent, the NPV would be –$14.6 million and the project would not be efficient.

Most Australian jurisdictions recommend use of the alternative producer rate of discount in the order of 7%.[9] This allows for non-diversifiable market risk which is the return generally available in private markets. This ensures that government adopts efficient projects that benefit **both** current and future generations (providing some surpluses are reinvested). Lower discount rates are likely to lead to adoption of more inefficient projects. The reasons for not adopting a project risk-adjusted discount rate are discussed below.

Two exceptions to this general strategy should be mentioned. First, when private investors provide capital for a project and bear part of the risk, the discount rate for their contribution should reflect the rate at which they are willing to part with their capital as this represents their perceived cost and required rate of compensation. Second, if the opportunity cost reflects loss of consumption rather than investment, a consumer or synthetic rate of discount would be appropriate. However, once capital is raised, there is always an investment opportunity cost.

Uncertainty and Risk

The technical literature on risk distinguishes between uncertainty and risk. An outcome is said to be uncertain when the probability distribution cannot be forecast. An outcome is risky when the outcome is variable, but the probability distribution can be estimated. There are rational ways of dealing with risk. It is much more difficult dealing with pure uncertain events. Accordingly, wherever possible analysts attempt to estimate probability distributions for uncertain events.

[9] On the other hand, many European jurisdictions recommend use of a time preference or synthetic discount rate. See for example HM Treasury (2011).

Similar issues arise in CBA studies. Where possible, economists attempt to quantify all major project costs and benefits. Such valuations, even when approximate, clarify trade-offs and reduce the risks of wild exaggeration. However, if impacts are highly uncertain they may not be quantified. Poor quantification can discredit the rest of the work. For example, it may be difficult to forecast biodiversity loss or to value a loss of Aboriginal heritage. Such impacts should be listed in a CBA. Decision makers can then decide whether they outweigh the quantified results.

Turning to the treatment of risk, Figure 8.2 illustrates the kind of choice that may be required. This shows the probability distributions of two projects A and B. Project B has the higher forecast mean and greater variance. A CBA typically estimates the mean (weighted average) outcome. However, government may prefer the project with less variance. What advice can economists give about this trade-off between means and variances?

Risk neutrality. We start by assuming risk neutrality (an indifference to the dispersion of outcomes) for two reasons. As we will see, there are strong technical arguments for government adopting a risk-neutral strategy.

To define risk neutrality, we must first define expected value (EV). EV is the weighted average value of the possible outcomes, weighted by the probability of their occurring. Assuming discrete outcomes with a probability summing to one, the EV of a project is the product of the forecast outcomes and their probability of occurrence:

$$EV = p_1 Y_1 + p_2 Y_2 + \ldots p_n Y_n \quad (8.21)$$

where p represents the probability, Y is income outcome and there are $n = 1 \ldots n$ scenarios.

An individual is risk neutral if he or she is indifferent between a certain outcome of $\$x$ and a prospect with uncertain outcomes but an expected mean value of $\$x$. To take a simple example, risk neutrality implies that a person is indifferent between receiving a certain \$1000 and a prospect offering a 50/50 chance of \$2000 or \$0, which would have an EV of \$1000. Risk aversion means that an individual would prefer receiving a certain outcome of $\$x$ to a prospect with uncertain outcomes and an expected mean value of $\$x$.

Although most individuals are apparently risk averse most of the time, Arrow and Lind (1970) showed that risk neutrality is generally the best strategy for a community. The reasons

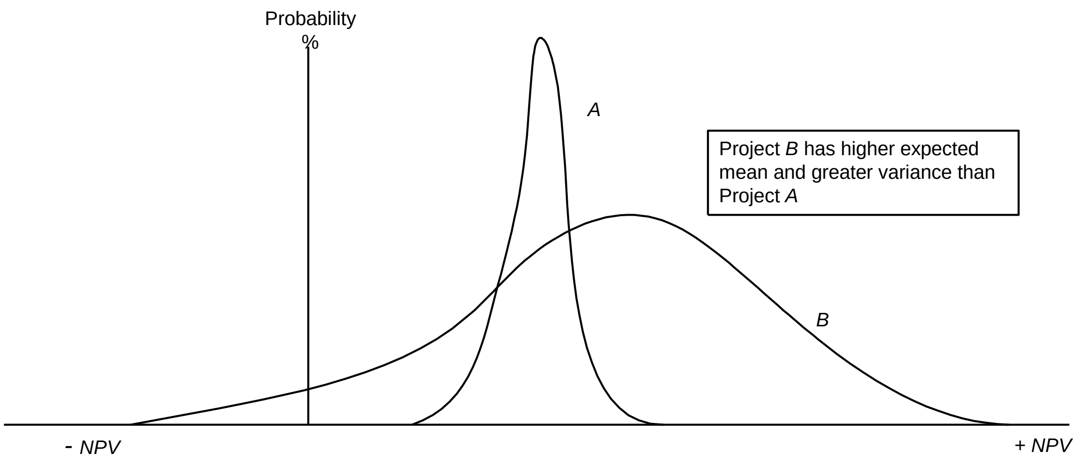

Figure 8.2 Forecast probability distributions for two projects

are risk pooling and risk spreading. **Risk pooling** occurs when risks are spread over a large number of projects. By the law of large numbers, the weighted average mean return on all projects will be achieved with little overall variance. Projects that exceed expectations offset those that underperform. Unless project risks are correlated, there is little risk to the aggregate return over all projects. **Risk spreading** occurs when the impacts of a project are spread widely over a large population and the impact on individual members of the community is small. This occurs when project costs are spread over many taxpayers. The smaller the impact, the closer are most people to risk neutrality.

Given risk neutrality, the efficient strategy is to select projects with the highest expected NPV. Suppose that project *A* has a certain NPV of $1.5 million and that project *B* offers a 50/50 chance of $5 million and –$1 million respectively. The expected NPV of *B* is $2.0 million and the expected value approach leads us to select *B*. Project selection based on expected values produces a higher aggregate return to society than does selection based on risk avoidance principles.[10]

However, risks cannot always be pooled or spread, for example for large projects in a small community. Where the risks are large relative to individual incomes, outcome variance becomes a significant issue.

Risk aversion. When variance matters, a measure of risk aversion (the preference of safety) is required. In effect, this means that we would like to know the certainty equivalent (CE) of the uncertain prospect. CE is the certain amount of income that would confer the same utility as a distribution of expected outcomes. For example, for a risk-averse individual, the CE for a prospect offering a 50/50 chance of $2000 or $0 could be, say, $700.

At community level, the CE is the amount of certain income that society collectively would be prepared to exchange for the set of uncertain outcomes generated by a project. Taking projects *A* and *B* above, distributional issues aside, society would presumably be willing to pay up to $1.5 million for *A*. However, it might not be willing to pay this amount for *B*. If the CE for *B* were less than $1.5 million, *A* would be preferred.

This implies that we can estimate CE amounts. This can be done in two ways. First, we can assume that risk aversion reflects the diminishing marginal utility of income as described in a standard concave utility function. In this case, CE values are the monetary equivalents of expected utility values which can be derived from assumptions about the nature of the utility function (see Rosen and Gayer, 2014, pp. 173–174). Secondly, CE values can be derived from household surveys. However, neither approach is commonly practised and, as a practical matter, alternative ways of handling risk are generally required.

One possible way is to raise the discount rate. This allows for the risk factor to affect the results directly and is a common practice in the private sector. However, it is not clear how much discount rates should be raised to allow for risk. Moreover, risks are not necessarily correlated with time so increasing the discount rate does not necessarily deal accurately with risk. Therefore, risk is rarely dealt with by raising discount rates in CBA studies.

In the absence of a valuation of the risk (via the CE principle or the discount rate), risk is generally treated descriptively. A comprehensive description would involve a complete mapping of the probability distribution, as shown in Figure 8.2. Where the number of uncertain variables is large, the input combinations can become very large. Various computer programs use sampling procedures with the number of iterations specified by the user. For continuous variables, the sample is drawn from a continuous distribution. The set of sample values is derived randomly and a probability distribution of results is generated from repeated

[10] Accurate calculation of expected values may require a large number of assumptions about probability distributions for variables and correlations of these distributions. This is impractical for most studies. Estimates of expected NPV are generally based on estimated mean values for each variable.

runs. Estimates of EV and variance can be derived from the resultant probability distribution. Decision makers then use this information to determine the preferred EV–variance trade-off.

A more common descriptive approach is sensitivity testing. Sensitivity tests show how the estimated NPV of a project (based on estimated mean values of variables) changes with variations in the values of inputs, such as construction cost or forecast demand. Sensitivity tests are practical and may reassure decision makers that outcomes are not sensitive to plausible changes in key variables. However, they provide an incomplete mapping. They also usually ignore the probabilities of high or low values of variables occurring (and so may over-emphasise extreme values that are unlikely to occur) and they ignore interdependencies between variables. For example, in a commercial project lower output may be offset by higher prices.

In conclusion, when risks are widely distributed and not correlated there are sound reasons why policy makers should aim to maximise expected NPV using a risk-free discount rate. When risks are not widely spread, they may wish to know the risk profile. This may be done by providing a comprehensive probability distribution of outcomes or by presenting sensitivity tests to policy makers rather than a single NPV figure. Policy makers must then decide whether to accept the risks. This may be informed by community attitudes to risk. But there is no mechanical formula to determine whether the risks should be accepted.

Distributional Issues

There are strong reasons for adopting an efficiency criterion of project value (i.e. estimated NPV). If this criterion were applied generally, most people would be better off (directly or indirectly) than if less efficient projects were regularly adopted. The indirect benefits arise because efficiency maximises collective project surpluses which can be redistributed via income transfers to compensate losers. Also, distributional objectives can generally be achieved more effectively and at less cost by income transfers than by individual projects.

However, income transfers may not produce an acceptable distribution of income. Also, losers from projects are often not compensated. Some projects with positive NPVs may benefit the rich and hurt the poor. Moreover, WTP values are based on the existing distribution of income. Because WTP rises with income, WTP measures may bias projects towards higher income households, especially when goods are provided free or at below-cost prices.[11] Therefore governments are often interested in the equity as well as the efficiency impacts of projects. This involves two steps: an analysis of distributional impacts and a policy determination.

Analysing distributional impacts. The analysis of distributional effects may appear straightforward, but it often has complications. First, the community must be divided into selected social groups because it is impractical to show the impacts on every individual. Groups may be chosen according to their nationality, income, age, sex, health status, area of residence and so on. Inevitably the selection of social groups involves value judgements. Second, when a project benefits firms, the benefits may accrue to shareholders, managers or employees, or government via taxes or consumers via lower prices. The role of prices is especially important. For example, lower production costs initially benefit firms. But, if the market is competitive, consumers will benefit from price reductions. Therefore, final impacts may differ from initial ones as impacts are shifted between groups. Third, transfer payments (mainly indirect taxes and subsidies) affect the distribution of costs and benefits although they do not affect total value of consumption. Fourth, secondary (flow-on) benefits can have significant distributional effects especially in regions where there are unemployed resources

[11] This problem does not arise when consumers pay the full costs of any service.

and potentially significant local multipliers. Evidently, a distributional analysis may require information, estimates and analysis that are not part of the basic CBA study.

Distributional impacts and decision making. As we saw in Chapter 7, estimated WTP dollar values of impacts can be converted into social utility values by using equity weights. In principle this provides an overall measure of social welfare inclusive of equity as well as efficiency.

However, we also observed that significant problems arise with the use of equity weights. The choice of weights is an ethical judgement not a technical exercise. There is no one standard set of generally acceptable weights available. Also, equity weights can produce confusing results. An unweighted NPV measures the gain in aggregate consumption. A weighted NPV has no clear meaning. Weights can lead to the uninformed adoption of inefficient projects and rejection of efficient ones. Nor does use of weights prevent adoption of projects with positive weighted NPVs that harm the poor.

In summary, policy makers often require information about distributional effects. Subject to careful analysis, this information can be provided along with the CBA. Policy makers may then weight the impacts as they see fit, but they should be well informed of the opportunity costs of the choices. There is no technical basis for the use of equity weights and their use may confuse rather than clarify the results for decision makers.[12]

CBA and Other Evaluation Methods

We consider below five other methods of evaluation. These include four that use a dollar metric and may be considered economic evaluation methods and one general non-economic method. Although all five evaluation methods are often used, none is as comprehensive or as rigorous as CBA.

Financial analysis
An account of the cash flows of a project for a specified agency

Financial analysis. This is an account of the cash flows (revenues and expenditures) of a project for a specified public or private agency. The format is like that of CBA in that cash flows are recorded over the life of a project and summarised via discounting in an aggregate figure, such as net present value. Unlike CBA, a financial analysis may incorporate financing arrangements and allow for projected inflation. Thus, a financial analysis may include interest payments, use market interest rates and include forecast general price changes.

A financial analysis shows how a project is to be financed and whether a financial profit or loss will be incurred. This is important for government budgeting and for sustaining an investment. However, it includes cash flows only for the specified agency and it does not include non-cash benefits or costs. Except in a perfectly competitive market with no externalities, a financial analysis presents only a partial picture of the costs and benefits of a project.

Cost-effectiveness analysis
Analyses the minimum expenditure required to achieve a given target

Cost-effectiveness analysis (CEA). This assesses the cost of achieving an outcome. Typically it is used to assess the least cost way to achieve a politically determined outcome. For example, CEA may be used to determine the least-cost way of servicing a forecast number of hospital bed days or of meeting an environmental target (say, an ambient air quality target). CEA may also be used to assess the least-cost way to raise a tax revenue target. In this case the aim is to determine the tax (or taxes) that minimise the deadweight loss arising from distorting the behaviour of firms and households.

[12] Despite these caveats against equity weights, CBA typically adopts standard equity values for life and travel time savings in order to avoid biasing outcomes in favour of higher income households.

CEA is employed widely where outcomes are determined politically. In these cases, CEA helps to achieve productive efficiency. However, compared with CBA, CEA is very limited because it does not value outcomes. It cannot be used to compare options with varying levels of output or to evaluate options with multiple outputs. Many policy issues cannot be reduced to cost-effectiveness issues.

National output analysis. Many policies are evaluated by reference to gross domestic product (GDP). For example, changes in interest rates or in fiscal policies, such as the carbon tax, may be assessed by their estimated contribution to GDP.

GDP can be a useful measure of the desirability of short-run macroeconomic management measures. Other things being equal, an increase in GDP is generally welfare enhancing. However, GDP is not a generally satisfactory measure of social welfare. GDP does not allow for externalities, non-marketed goods, the value of leisure, terms of trade effects or national versus foreign interests. It is therefore an inappropriate evaluation criterion for many major public policies or projects.

Economic impact analysis (EIA). This usually means analysis of the income impacts of a project in a selected region. Typically, the local income impact (ΔY) of a project is estimated as a function of the local expenditure (E) and the multiplier (M):

$$\Delta Y = E \times M \tag{8.22}$$

$$M = 1/(1 - MPCL) \tag{8.23}$$

where $MPCL$ is the marginal propensity to consume locally produced goods. The multiplier falls as $MPCL$ declines. $MPCL$ declines with three main leakages: taxes, savings and expenditures on imports to the region. Suppose that taxes and savings account for 30 and 10 per cent of marginal income respectively, and that imports account for half of the 60 per cent balance that goes to expenditure. Then $MPCL$ = 0.30 and M = 1.43. Suppose that an externally financed project costs \$10 million, with half spent on local resources. The estimated gross regional income impact would be (\$5m × 1.43) = \$7.15 million.

However, this assumes that local employment (at primary and secondary stage) has no opportunity cost. Suppose that of the \$5 million spent on local resources, \$4 million employs resources that would be otherwise employed in the absence of the project. The net local income effect would be \$1m × 1.43 = \$1.43m. This is a much more modest result than is typically found in an economic impact analysis. The result would be lower still if the secondary (multiplier) employment has any opportunity cost. We should also note that a CBA would include a \$1 million project benefit for the employment of otherwise unemployed resources.

Done properly, EIA studies can show the net regional income impact. But they have several weaknesses. They are limited geographically and ignore non-monetary effects. They regard expenditures as benefits rather than as (opportunity) costs. Thus, the economic effect is always positive, which is why industry groups like such studies. But an effect that is always positive is of little help to policy makers.

Multi-criteria analysis (MCA). This has various forms and names, for instance planning balance sheets, goals achievement matrices, point scoring methods and so on. But essentially there is a single underlying method.

Table 8.3 Simple example of multi-criteria analysis

Criterion	*Criterion weight*	*Project A*		*Project B*	
		Score out of 100	*Weighted Score*	*Score out of 100*	*Weighted score*
Travel time	40	80	32	50	20
Environment	30	40	12	80	24
Total cost	30	30	9	60	18
Total	100		53		62

First, the analyst establishes the objectives (or criteria). In the simple example in Table 8.3 the criteria are travel time savings, environmental benefits and cost. Second, weights are attached to each criterion that reflects its importance, in this case 40, 30 and 30 respectively to an arbitrary total (here 100). Third, each option (here projects *A* and *B*) is scored against each criterion (again here they are each scored out of 100). The score measures the extent to which each option meets the respective objective. Fourth, weighted score (the product of the criterion weight and the score) is estimated. Finally, the weighted scores are added to a total.

The MCA method helps to organise issues systematically and transparently. Policy makers can then make trade-offs between objectives. However, there is subjectivity and arbitrariness at all the main points in the process: in selecting criteria, in allocating weights to each criterion and in estimating points for each option for each criterion. The fundamental weakness of MCA and virtually all non-economic methods of valuation is that, unlike CBA, they are not based on any valuation principles. In the absence of such principles the evaluation process is wide open to manipulation.

Conclusions

CBA is the only form of economic analysis that presents a complete welfare assessment. CBA is based on principles of value and provides practical methods to implement these principles. CBA provides transparent, testable and efficient results. The other forms of economic analysis are all incomplete in one or another way.

However, positive net social benefits are not always equitable. The simple aggregation of WTP amounts can result in well-off individuals gaining at the expense of less well-off individuals. Also, the future is inherently uncertain and forecasts, often based on hard-to-forecast inputs from other disciplines, are inevitably subject to ranges or variance.

Economists have an important role in estimating efficiency/equity trade-offs and plausible ranges of outcomes so that decision makers are fully informed. However, determining the preferred efficiency/equity outcome and the preferred amount of risk aversion/safety are ultimately political issues.

Summary

- Cost-benefit analysis is the most common and comprehensive form of economic evaluation.
- CBA is based on the valuation principles of welfare economics. It values the costs and benefits in monetary terms as they would be valued by the parties affected.
- The estimated net present value shows whether expected benefits exceed costs. If the estimated NPV is positive, a project or policy is described as efficient.
- The internal rate of return and the benefit-cost ratio are other summary measures of project efficiency.
- Market prices often provide accurate indicators of marginal benefits and costs. However, where prices do not fully reflect social values, estimates of consumer surpluses and shadow prices are needed.
- Future costs and benefits are discounted to present values. In Australia, this generally involves using the return on alternative investment as the social rate of discount.
- When risk is widely spread, maximising expected NPV is usually an efficient and fair strategy. However, when a policy entails significant risk for some group(s), policy makers may wish to know the likely variance in outcomes as well as the expected mean outcome.
- When the distributional impacts of a policy adversely affect some social group, especially a disadvantaged group, an analysis of distributional impacts is likely to be required. However, equity weights are rarely employed.
- Other methods of evaluation include financial analysis, cost-effectiveness analysis, GDP studies, economic impact analysis, and multi-criteria analysis. None is as comprehensive or as rigorous as cost-benefit analysis.

Questions

1. Consider two projects, *A* and *B*, with capital costs of $100 million and $20 million respectively. Given an opportunity cost of capital of 7 per cent, *A* provides an NPV of $30 million. *B* provides an NPV of $10 million. Explain why *A* is better than *B*, although it costs five times as much and produces only three times the net benefit.
2. Is the net present value always the best measure of project value? When might other measures of project value be preferred?
3. In a CBA, what is an appropriate price for using a tonne of steel: the domestic market price, the market price less indirect taxes or an import or export price?
4. Suppose that the government pays Amy $120 per day to work on a new project. Amy has a leisure preference of $60 a day and currently receives an unemployment benefit of $30 per day. What is the social cost of employing Amy on a public project?
5. Does the cost of finance for a project affect the discount rate? Why is the government borrowing rate generally not the appropriate discount rate?
6. Should the opportunity cost of capital discount rate or the social time preference rate of discount be applied to assess projects to reduce greenhouse gas emissions and long-term global warming? Explain your answer.
7. What are the weaknesses of sensitivity tests as a means of informing policy makers about the variance of project outcomes?
8. Can certainty equivalent amounts be estimated? Is this a useful tool for evaluating uncertain outcomes?
9. Why may cost–benefit analysis show that it is efficient to locate polluting industries in poor countries? If this is the case, does this discredit cost–benefit analysis?
10. If a national highway is substantially upgraded and freight costs between two cities are reduced by 30 per cent, who would benefit: the trucking firms using the highway, the business shipping freight or consumers? Give reasons.
11. The government is considering constructing a new urban freeway for $500 million. This would save 30 000 commuters 10 000 hours a day (10 minutes each way) for 200 days a year. Suppose that the road can be built in one year, commuters value their travel time savings at $20 per hour and the road has a life of 30 years after year 1 and a residual value estimated at cost at $500 million in year 32. There are no other costs or benefits.

    i. Would the road provide a net social benefit with a discount rate of 7 per cent?

    Now suppose that the government charges a road toll of $2.50 each way and that traffic falls to 20 000 commuters twice a day.

ii. What would be the financial outcomes using a 7 per cent discount rate?

iii. What would be the net social benefit if the remaining commuters had an average value of travel time of $25 per hour?

iv. What are the implications of the road toll?

12. When, if ever, should other evaluation methods be preferred to cost–benefit analysis?

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