9 Overview of cost-benefit calculations: present value, rate of return and cost-effectiveness methods

This section examines the main formulae used for investment decision rules and how they can accommodate the problem of interpersonal comparisons. As mentioned previously, the essence of cost-benefit analysis is to make clear to policy makers that expenditure on one program is always at the expense of expenditure on an alternative program.[12]

When one person benefits from program A but another person benefits from program B, a value judgement must be made as to which program is preferred. Questions to consider are: Is program A preferred only if the monetary benefit received by beneficiaries is greater than program B? If the beneficiaries of program A are wealthier, or have more promising lifetime prospects than the beneficiaries of program B, is program A still preferred?

Cost-benefit analysis formulae

There are three main formulae used in cost-benefit analysis: net present value, rate of return and cost-effectiveness calculations. This section provides overviews of these methods and the subsequent section deals with the issues of the societal distribution of costs and benefits and the choice of discount rate.

Net present value

The net present value (NPV) is an overall measure of the difference between the costs and benefits of an intervention. Intuitively, if the intervention contributes more benefits to members of society than the costs it imposes on society, then there is an argument for implementing the intervention. However, the time period in which the costs and benefits are generated or received can vary, so the costs and benefits need to be reduced to a single comparable time period by some method. For example, if an early childhood intervention promises to produce a benefit of $100,000 in 50 years time through reduced crime, it is debatable whether this is of equal value to society of a benefit of $100,000 in one years time.

In general, it is commonly assumed that more distant benefits and costs are of less value than near ones. It is assumed that the value of costs and benefits incurred and received differs according to the time periods, so the costs and benefits are weighted according to the time period in which they fall. Thus, a single overall summary figure can be derived for the intervention. In general, the formula for net present value, discussed below, assumes that each additional year into the future is discounted at a constant rate. However, this need not be the case and the rate of discount can be negative (implying that more distant costs and benefits are valued more that near costs and benefits) or differ for each selected year.

In general terms, given a stream of benefits, $B_0, B_1, B_2 \ldots$ and costs $C_0, C_1, C_2 \ldots$, the formula for the net present value (or NPV) is:

$$NPV = (B_0 - C_0) + \frac{B_1 - C_1}{(1+r)} + \frac{B_2 - C_2}{(1+r)^2} + \ldots + \frac{B_n - C_n}{(1+r)^n}$$

12 Here the term "expenditure" is used in a broad sense to include a program of tax reduction.

or, more briefly,

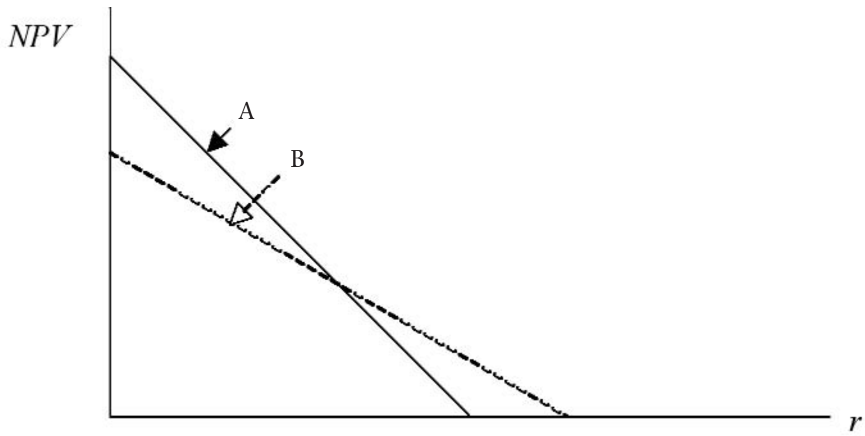
$$= \sum_{t=0}^{t=n} \frac{B_t - C_t}{(1+r)^t}$$

where *r* is the rate of discount and the sub-scripts *0, 1, 2…*refer to each time period with *0* representing the start of the intervention. When comparing projects, *r* should include a premium for the risk and uncertainty associated with predicted future benefits and costs.

If costs are one-off and concentrated in the initial time period (such that $C_1 = C_2 = C_n = 0$) and the stream of benefits (*B*) is constant and infinite ($n = \infty$), then

$$NPV = \frac{B}{r} - C_0$$

Both benefits and costs need to be reduced to a common denominator, usually money. The investment decision rule is either to invest in all interventions that have a net present value greater than zero, or alternatively to rank interventions according to their net present value. However, the net present value is sensitive to the chosen rate of discount. In the example below, intervention A has a higher net present value at low rates of interest while intervention B dominates at higher rates of interest. This will occur because the benefits arising from A are from a more distant time period than B.



Net present value (NPV) can only be used in circumstances where the main costs and benefits of an intervention can be reduced to a common unit of account, usually money. This ensures that the value to the participant and society of higher wages, a more rewarding job, less crime and less social dislocation can be monetised in a meaningful way. If the methods used to monetise these effects are not well accepted by policy makers then this method of deciding between interventions should not be used.

Rate of return

The rate of return formula uses many of the same assumptions as the net present value referred to above, but instead of calculating a single measure of net benefits at a given discount rate, it estimates the discount rate that is required to produce a single net benefit measure of zero. The rate of return, λ is derived from the formula:

$$0 = (B_0 - C_0) + \frac{B_1 - C_1}{(1+\lambda)} + \frac{B_2 - C_2}{(1+\lambda)^2} + \ldots + \frac{B_n - C_n}{(1+\lambda)^n}$$

or, more briefly,

$$0=\sum_{t=0}^{t=n}\frac{B_t-C_t}{(1+\lambda)^t}$$

where *t* is the time horizon for the intervention. The investment decision rule is to invest in all interventions with an internal rate of return greater than the societal rate of time preference. The latter is the rate at which the average member of society is prepared to forego benefits in the current period, in order to receive benefits in a later period. If for example, if the average citizen is prepared to forego $100 worth of consumption today, only if he or she is certain they will receive at least $105 next year, then the rate of time preference is 5 per cent. Rates of time preference can be negative. A person may be willing to give up $100 today in order to be certain to receive $95 next year (possibly because their income from other sources is expected to fall), in which case the rate of time preference is -5 per cent.

Cost effectiveness

Cost effectiveness approaches are used when it is not considered meaningful to monetise the benefit streams, and the investment criterion is reduced to ranking the costs of achieving the same goals through different interventions. For example, raising the school retention rate for a target population may be achieved by preschool programs, parent education and awareness programs or direct financial incentives to families. In this case, the investment decision criterion would be to minimise the new present value of costs:

$$NPC=C_0+\frac{C_1}{(1+r)}+\frac{C_2}{(1+r)^2}+\ldots+\frac{C_n}{(1+r)^n}$$

where NPC is net present costs.

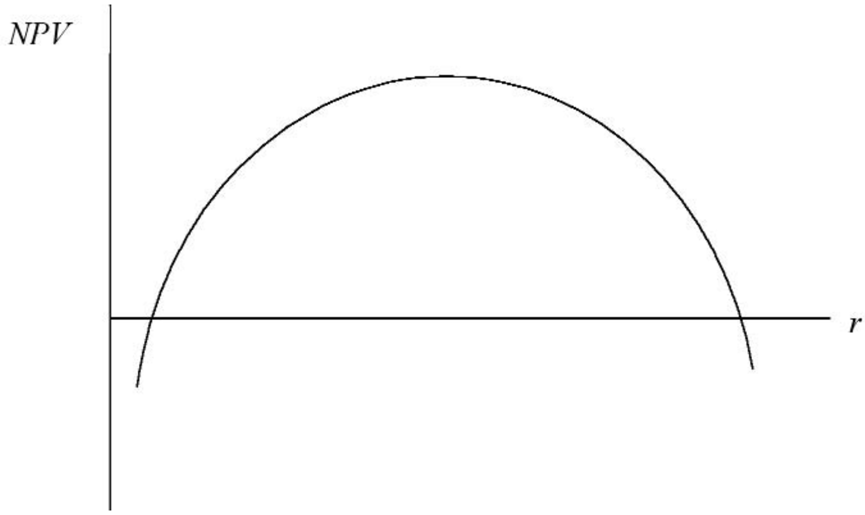
Which measure is superior?

The cost effectiveness rule is a superior decision rule only when the benefits are homogeneous and thus quantifiable across alternative interventions. It would be appropriate then to use this rule when comparing two or more interventions to increase school retention or reduce the number of criminal assaults. As soon as interventions have more than one type of benefit, or the benefits vary in quality to such an extent that they cannot be quantified in a meaningful way, then the cost effectiveness approach cannot be used. In this instance, the net present value and rate of return formulae should be used.

In general, these two approaches will give different rankings depending on either the chosen rate of discount or the chosen time period, leading to some ambiguity in the investment decision-making instrument. The calculation of the internal rate of return is, however, sensitive to the chosen time horizon (*t*). Layard (1972: 51-52) argues that there are three main reasons for preferring the net present value as a decision rule:

- The net present value can accommodate variations over time in the discount rate which the rate of return approach cannot.
- The rate of return approach incorrectly ranks interventions of different size or interventions of different time horizons. This is not an issue if the projects are completely divisible and duplicable (maintaining the same stream of costs and benefits *pari passu*), but in this case the rate of return approach will give the same answer as the net present value. Thus the rate of return metric is equivalent but not superior to the net present value metric.
- The rate of return calculations may not give a unique answer and may give many solutions, as shown in the diagram below. A given project has a unique set of net present value for each rate of discount, but net present value may equal zero at two rates.

In short, the rate of return provides a less general approach than the better defined net present value (or NPV).



Societal distribution of costs and benefits

Cost-benefit analysis aims to produce an index for the net societal benefit from a given investment project to enable decision makers to decide either whether a project should proceed, or how to rank projects by value. It calculates a single figure by simply summing costs and benefits across individuals and is therefore neutral with respect to the types of individuals who will benefit the most from one intervention or the other. However, it may so happen that intervention A may benefit (or disadvantage) community Y the most, while intervention B benefits (or disadvantages) community Z more. It almost always happens that intervention A will affect distinct individuals in a different way from intervention B, whether or not they belong to the same community or group.

In the example of early childhood interventions, there are very clear potential income distributional effects. Many of the proposed benefits from running early childhood interventions are intended to directly affect the participating child in the form of better health, higher wages and a more rewarding labour market experience. As such, society as a whole, through the payment of taxes, has made the investment for the localised benefits of selected groups in society, but see discussion of spillover effects in Section 10. This is a subjective policy decision.

To make this subjective process more transparent, cost-benefit analysts may choose to weigh the benefits and costs according to a set of subjective distributional values (see Weisbrod 1968: 814). In this way, a series of indices, based on different subjective weights, may be calculated, and the decision maker can see how sensitive the project rankings are to the subjective weights. Generally however, distributional differences have no formal place in the cost-benefit formulae, but since they are clearly relevant decision-making criteria for public policy, they are treated discursively in the text that accompanies the evaluation.

Intertemporal discount rate

An investment is by definition, a current outlay made in the expectation of a future return. The decision maker therefore is always comparing values over time and must make some choice about whether to discount, or appreciate, future dollar values relative to today's dollar. For business, this is straightforward. Since they must borrow money for investment, either from a financial intermediary or their shareholders, the cost of having funds tied up in an investment project is the market rate of interest plus an allowance for the risk and uncertainty of the project.

For public policy makers, the issue is about the cost of deferring today's consumption (this includes consumption of welfare products) until some time in the future. Clearly, if the labour and resources used for an investment are currently unemployed or not used, then there is no deferral of today's consumption and the discount rate is zero.

However, investments that only involve otherwise unemployed resources are rare, and the general case will be when the project(s) involve scarce labour who would otherwise be employed in other welfare enhancing work. The appropriate rate of discount represents how much of today's consumption is foregone in order to consume tomorrow. For example, if 91 cents is foregone today in order to consume $1.00 tomorrow, then the rate of discount is 10 per cent.

While rates can be estimated by surveying people and asking them what they personally would give up today in order to get a specified amount in the future, interpersonal comparisons cannot be estimated this way. In particular, this method cannot be used to estimate inter-generational discount rates. Today's citizens should not be entitled to put a maximum rate on how much of today's consumption they should forego in order to benefit, or not benefit, future unborn generations, or decide if future generation's welfare should be discounted at all, especially when much of today's consumption is derived from the natural endowment. This is not a question of today's parents deciding on how much to invest for their own children. In matters of public policy, it is today's members of society collectively determining the discount rate for the collective population of tomorrow.

With respect to early childhood interventions, the choice of discount rate will affect the ranking and net present value calculation of interventions where the benefits are concentrated in the school age period, early adulthood or late adulthood.

While there is no certain correct answer to the question of the appropriate rate of time preference, positive discount rates are generally used for the simple practical reason that projects with zero or negative discount rates and infinitely lived benefit streams do not converge to a present value.