5

What not to do: A 'belts and braces' enhancement of harmonisation

Introduction: Common misconceptions in cost-benefit analysis

A range of agencies in the Australian and New Zealand jurisdictions occasionally publish manuals, fact sheets and guidelines to assist their staff in preparing or commissioning studies employing cost-benefit analysis (CBA). Examples include the New Zealand Treasury (2015), Department of Finance and Administration (2006) and Transport for NSW (2013). An obvious advantage of publishing manuals and guidelines is that individual agencies reinforce their advocacy of the use of CBA in evaluating project proposals.

One, possibly unintended, consequence of publishing manuals and guidelines is that they foster a degree of harmonisation between agencies and even between jurisdictions. Most agency manuals cover similar topics and generally cite or copy sections of other agencies' manuals and guidelines. The Department of Finance and Administration (2006) *Handbook of Cost-Benefit Analysis* is an exception in that it refers almost entirely to academic publications, although it is often itself cited by other agencies in their manuals.

Preparation and publication of a manual or handbook requires considerable effort. No matter how skilled an author in a government agency, he or she will inevitably face reviews of multiple drafts by superiors and others in the organisation. Considerable resources are ultimately devoted to the production of a CBA manual. It is therefore pertinent to ask whether publication of manuals by individual agencies is an effective use of resources, and whether the contents could be improved in some way. Several perspectives are relevant.

Given the number and range of textbooks of various levels of sophistication that are readily available, an obvious question to ask is why agencies bother to replicate or rewrite published, peer-reviewed material. One answer might be that manuals are intended to distil concepts and methods that may be expounded at greater length and in a more theoretical context in academic textbooks. Abstraction from a theoretical context in an area like CBA, however, risks misapprehensions and mistakes of the sort dealt with in the examples examined in this chapter.

A second issue relates to the degree of detail and level of sophistication that should be incorporated into a manual. The problem is that a mixed readership requires different levels of information and explanation. Officials in specialised government agencies are likely to become bored with basic material, making little use of a publication. On the other hand, overly succinct explanations or instructions are likely to leave novices puzzled. An example is the frequent reproduction of the present value formula: unnecessary for those who already understand the concept of discounting, but unnecessarily confusing to those not used to interpreting mathematical formulae.

Manuals tend to be written in a prescriptive manner that informs users about what is to be done in an appraisal. Some point to the pitfalls of standard problems such as double counting. In general, however, they fail to clarify or specify what should *not* be done. A 'belts and braces' approach that also advises what should be avoided would aid comprehension and the quality of CBA studies.

It is important to be explicit about undesirable methodologies. An example is the treatment in CBA of employment creation, a topic of interest to most decision-makers at the political level. The need to take into account political considerations has generally been handled

adroitly by recommending that job creation should be 'reported separately' to the results of the CBA itself. Despite the neatness of the solution, there is nevertheless a risk of fostering the erroneous perception among readers that 'jobs' are in fact an additional benefit, on top of other quantified benefits.

Recommendations

- Manuals and handbooks on CBA that are produced by agencies should specify methodologies that are not considered to be desirable, with explicit explanations for why this is so.
- Agencies should consider the relative value of supplementing official manuals with training courses that provide a fuller context to the contents of manuals and handbooks.
- Publication of CBAs should be encouraged as a means of fostering wider discussion of methodology and the values used.

5.1 The misconception that the purpose of discounting is 'to allow for inflation'

A not uncommon misconception among public servants is that discounting means 'allowing for inflation'. It is possible that the confusion arises because the arithmetic used in making adjustments for inflation is similar to that used for discounting.

CBA provides a comparison of the sum over time of the additional projected benefits and the sum of the additional attributable costs of a proposed project or policy. Adding up costs and benefits requires that they be expressed in common units or mathematical 'dimensions'. Ensuring commensurability should ideally involve, at a minimum, adjusting values to reflect their receipt or incidence at different periods of time, expressing them consistently in either real or nominal values, and adjusting for risk.

Placing discounting, inflation-adjustment and risk analysis within the broader context of commensurability is a useful means of avoiding confusion among generalists who may not be familiar with the different concepts. There is no single, fixed method of conducting a CBA, so it is important to stress the underlying concept of commensurability,

rather than simply prescribing discounting. The following section demonstrates that it is possible to work in either real or nominal values, provided all variables are expressed in consistent units. A similar illustration could be provided for the adjustment of costs and benefits for risk.

5.1.1 Real versus nominal: Does it really matter?

It is typically the case that costs and benefits are first converted to real values and then discounted by a rate that is also expressed in real terms. The same result could be obtained, however, by working exclusively with nominal values for both the benefits, costs and the discount rate, with no adjustments for inflation. Table 5.1 compares the two approaches.

Table 5.1: Discounting with real and nominal values

	Nominal values		Real values (t = 0)	
Period	Annual benefit	Discounted at 5% per annum	Annual benefit inflation 2% p.a.	Discounted at 3% p.a.
1	$10	$9.52	$9.80	$9.51
2	$10	$9.07	$9.61	$9.06
3	$10	$8.64	$9.42	$8.62
4	$10	$8.23	$9.24	$8.21
Present value		$35.46		$35.40

Source: Leo Dobes

Ignoring the difference due to rounding error[1] when working with exponential values, it is clear that the same result can be obtained by working in nominal values only, or in real values alone. The key issue is that the 'dimensions' of the values used (benefits, costs, discount rate) in either approach must be consistent with each other.

In practice, it is difficult to forecast future values in nominal terms. For example, forecasting the cost of petrol for each year for the next 15 years is fraught with difficulty because observed prices at the pump are likely to fluctuate during the year, as well as between years. A workaround is to choose a long-term average value and treat it as a

1 The two approaches are in fact mathematically equivalent. Sugden and Williams (1978, s. 3.5) provide a short but elegant proof.

real cost. For example, a cost of about $1.20 per litre might be chosen as a long-run average, without being adjusted any further for inflation on the assumption that it will increase at approximately the same rate as all other prices. The present value of petrol costs over the 15 years would then be obtained by applying a real discount rate.

5.2. Qualification of the decision rule that a BCR > 1 or NPV > 0 indicates that a project should proceed

It is not uncommon for proponents to claim that projects should proceed because their benefit-cost ratio (BCR) is greater than 1. At first glance, such calls seem unobjectionable because a BCR ratio that exceeds unity implies that benefits exceed costs. The use of BCR therefore offers a readily accepted decision rule. In practice, the reality may be different.

5.2.1 The standard benefit-cost ratio and the net present value decision rule

The most common, standard use of a BCR refers to a ratio of the present value of all the benefits, divided by the present value of all the costs (including capital and operating).

$$BCR = \frac{present\ value\ of\ all\ benefits}{present\ value\ of\ all\ costs\ (including\ capital\ and\ operating)}$$

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

A better alternative to citing a BCR is to refer to the net present value (NPV) which equals the present value of all social (private plus public) benefits minus the present value of financial operating and capital costs, as well as economic costs like externalities. Table 5.2 illustrates the importance of presenting costs and benefits separately.

Table 5.2: Comparison of standard benefit-cost ratio (BCR) and net present value (NPV)

	Project 1	Project 2	Project 3
Present value of all benefits	11	1100	11
Present value of all costs	10	1000	9
Benefit-cost ratio	1.1	1.1	1.2
Net present value	1	100	2

Source: Leo Dobes

At first glance, Project 3 appears to be the superior alternative in Table 5.2 because it has a BCR of 1.2, while projects 1 and 2 have BCRs of only 1.1. On the basis of BCRs, projects 1 and 2 are also equivalent in merit. On the basis of BCRs alone, a decision-maker would choose Project 3, and remain indifferent between projects 1 and 2 if a second choice were available. The problem is that ratios do not clearly distinguish between the numerator and denominator so it is not clear how relatively attractive they are.

Use of NPV, on the other hand, is comparatively unambiguous, with Project 2 clearly showing the greatest contribution to economic welfare in absolute terms. In comparison, the relatively small NPV values for projects 1 and 3 suggest that they would be eliminated from further consideration. While BCRs may be preferred by some project proponents for presentational reasons, NPVs are a more transparent approach for displaying the result of a CBA and should be preferred to a BCR in presenting the results of a CBA.

It may be argued that an NPV by itself does not inform the decision-maker how large the difference between social costs and social benefits may be relative to the overall social cost. The cost of a project, however, is not itself relevant to decision-making in CBA. What is relevant is the magnitude of the additional benefit that can be gained from an additional social cost, taking into account feasible alternative projects.

Nevertheless, the standard decision-making rule of NPV $>$ 0 that is presented in some texts should not be applied automatically or indiscriminately.

5.2.2 When use of the NPV > 0 criterion alone may be problematic

Even if NPV > 0 or BCR > 1, there may be better projects available with a higher NPV. The point is that a positive NPV or a BCR that exceeds unity are not in themselves sufficient to conclude that a project should be implemented. Overall social well-being can be increased by selecting alternatives with the highest NPVs. For example, a school or hospital may have a higher NPV, even if the focus of a particular study is on the construction of better roads. Special interest advocates typically ignore alternative potential uses of social resources, sometimes in the genuine belief that the social merit of their proposed project is self-evident and should therefore be given precedence.

Further, there are three specific situations when use of NPV > 0 is not necessarily an appropriate decision criterion:

- where there is a budget constraint in a given year that precludes the financing of all the projects that yield a positive NPV
- where two or more projects have different lives: a longer time horizon is likely to involve the accretion of more costs and benefits, so that a project with a shorter life cannot be validly compared with a more protracted one
- if a real (quasi) option is present: the flexibility of not needing to invest fully at the start of the project in a situation of uncertainty generates additional value that should be added to the NPV. The topic is too complex to address succinctly below, but see, for example: Dixit & Pindyck (1994), Trigeorgis (1996), Treager (2014), *The Economist* (1999, August).

5.2.3 Selecting projects under a budget constraint

In a situation of limited budgetary resources, it may not be possible to fund every project that demonstrates a positive NPV. Giving preference to projects with the highest NPV may not maximise overall NPV, especially if projects with high NPV also require a high level of initial funding for their implementation. It is possible that selection of lower NPV-yielding projects can maximise overall NPV. Table 5.3 illustrates this possibility.

Table 5.3: Ranking of projects by NPV and profitability ratio ($ thousands)

Project	PV (K)	PV (B)	NPV (rank)	B/K (rank)
A	100	130	30 (5)	1.30 (2)
B	400	433	33 (4)	1.08 (5)
C	200	303	103 (1)	1.52 (1)
D	400	494	94 (2)	1.24 (3)
E	500	558	58 (3)	1.11 (4)

Note: K = capital cost of investment; B = benefits net of operating costs; B/K = net benefit investment ratio (NBIR): also known as the profitability ratio

Source: reproduced from Table 3.3 in Campbell & Brown (2003)

Table 5.3 compares five fictitious projects ranked by their NPV (4th column) and by their rank on the basis of the net benefit investment ratio (NBIR, 5th column). The NBIR can easily be confused with the standard BCR. However, rather than including only benefits in its numerator and all costs in the denominator, as for the standard BCR, the NBIR includes in its numerator benefits minus operating costs, with the denominator being limited to the capital or investment cost alone. An alternative term for the NBIR could be the profitability ratio because it shows the net return on the initial investment.

$$NBIR = \sum_{t=0}^{n} \frac{(B-C)_t}{(1+r)^t} \Big/ \sum_{t=0}^{n} \frac{K_t}{(1+r)^t}$$

Campbell and Brown (2003) posit an $800,000 limit on financial resources with decision-makers faced with the projects shown in Table 5.3. If the projects with the highest NPV were given preference by decision-makers, projects C and D would be funded first, and then 40 per cent of project E, assuming that it could be part-funded. The overall NPV achieved would be $220,000.[2] If, instead, decision-makers ranked projects according to the NBIR, they would choose projects C, A, D, and 20 per cent of project E, yielding an overall NPV of $239,000.

2 NPV = $103 + $94 + 0.4*$58 = $220,000

In cases where projects are indivisible, it may still be possible to choose a set that have generally lower NPVs individually, but together yield a higher overall NPV within the budgetary limit. The NBIR can again be used to rank such 'lumpy' projects.

Brealey et al. (2006, ch. 5.4) point out, however, that the use of NBIR to rank projects subject to a budget constraint is 'inadequate whenever there is any other constraint on the choice of projects'. Examples of constraints include cases where one project depends on another or two projects are mutually exclusive, or there is a budget constraint in more than one year. In such cases, resort to linear programming methods may be required to identify an optimal set of projects.

5.2.4 Comparing projects with different lives

Projects with different timeframes cannot be compared directly on the basis of their NPV values. The longer of the two project periods will accrue a greater number of benefits and costs than the shorter one. It would therefore not be appropriate to compare the two on the basis of NPV alone.

One means of validly comparing projects with different time horizons using only NPV is to replicate them in a way that results in the same period for both. For example, a two-year and a three-year project would be replicated three times and two times respectively, so that both are six years long. However, this approach may not always be practicable — for example, if one project is seven years in length and the other nine years — because the common time period may be too long. A lengthy time period necessarily needs to assume that technology and other conditions remain the same; otherwise a comparison over the extended time period becomes unrealistic.

Table 5.4 illustrates the alternative approach of deriving equivalent annual values (EAV) by converting NPVs into annuities. A government agency needs to choose between two types of motor vehicles its senior management. They are of equivalent quality and performance but differ in price and length of effective life. Vehicle A costs $25,000 to purchase, with annual maintenance costs of $6,000. It is kept for three years and then sold for $5,000 at the end of the third year and then replaced with the same vehicle type. From the annuity table, the annuity factor for 3 years at 5 per cent p.a. is 2.72. Vehicle B costs

$20,000 to purchase, with annual maintenance costs of $7,000. It is kept for only two years and then sold for $5,000 at the end of the second year and then replaced with the same vehicle type. The two-year annuity factor in the annuity table is 1.86 at an interest rate of 5 per cent per annum.

Table 5.4: Using EAVs to compare projects with different time horizons ($ thousand)

	C_0	C_1	C_2	C_3	PV @ 5% p.a.
Vehicle A	25	6	6	(6-5) = 1	37.01
EAV		13.61	13.61	13.61	37.01
Vehicle B	20	7	(7-5) = 2	-	28.48
EAV		15.31	15.31	-	28.48

Note: EAV = equivalent annual value; PV = present value

Source: Leo Dobes

Because the PV of the costs for vehicle A ($37.01) is higher than for vehicle B ($28.48), the decision rule of choosing the least cost vehicle, vehicle B would be chosen. If the vehicles were being bought and replaced over a longer period (e.g. 10 years) then it would be financially more favourable to use vehicle A, because its annualised value of $13.61 is lower than that for vehicle B ($15.31).

Conversion of NPV values to EAVs permits direct comparison of the two machines on the basis of annualised constant costs. The EAVs are derived by dividing the NPV of each by the annuity factor corresponding to the life of each project. For example Machine A has a PV of $28.37. Dividing the PV by the annuity factor for three years at a 6 per cent per annum discount rate (equal to 2.673) provides an EAV of $10.61. Comparing the two machines on the basis of annualised values leads to a decision to choose Machine A, even though the PV of its costs is higher than that of Machine B.

The EAV approach is sometimes also used for projects where there are large costs at the end of the project, as well as large capital costs at the beginning of the project. An example might be a comparison between a nuclear power station and a coal-fuelled one, where decommissioning costs are incurred. In such situations, there is a reversal of the sign of

cash flows — from initially negative during construction, to positive during the operational phase, and then to negative again when decommissioning occurs.

In sum, NPV should be used as the decision criterion for CBA. Care is required to ensure that NPVs are used validly, however, especially where projects with different time horizons are being compared. It is also desirable to present as much information as possible to decision-makers, rather than providing only an NPV. Itemising all social costs and social benefits is particularly desirable.

5.3 The furphy that the period of analysis should not exceed 30 years because the effect of discounting is to make any present values negligible after this length of time

There are no hard and fast rules for the time horizon of a project. The relevant timeframe should be determined by the period over which impacts are typically expected, rather than any effects of discounting. Nevertheless, even respected publications like *The Economist* (for example, 26 June 1999, p. 94) may on occasion recommend a time horizon not exceeding about 30 years for discounted cash flow analysis.

Table 5.5: Present values of $1 for selected years and discount rates

Years	3% p.a.	5% p.a.	10% p.a.
10	0.74	0.61	0.39
20	0.55	0.38	0.15
30	0.41	0.23	0.06
40	0.31	0.14	0.02
50	0.23	0.09	0.01

Source: adapted by Leo Dobes from appendix 2, Campbell & Brown (2003)

Table 5.5 presents a selection of years and discount factors for present values. It is clear that, even with a 5 per cent per annum discount rate, the present value of $1 is still almost a quarter (0.23 cents) after 30 years. A similar figure holds after 50 years if the discount rate is only 3 per cent per annum. Even a relatively high discount rate of 10

per cent per annum would see approximately 1 cent in every dollar preserved at the 50-year mark. It is therefore not clear why blanket advice should be given to avoid exceeding periods of 30 years for discounting project costs and benefits.

5.4 Caution required regarding treating increased property prices around a new road or railway as a benefit

It is obviously important to distinguish between the various effects of a project when conducting a CBA.

Primary effects are typically those that reflect most closely the purpose or objective of the project. In the case of a dam that is constructed to reduce flooding, the primary effect will be to reduce flood damage, but there may also be ancillary or associated costs or benefits that need to be attributed to the project. For example, the dam may be constructed in such a way that it also produces hydroelectricity, or it may result in the negative externality of exterminating a fish species that requires a free-running river.

Analysts are sometimes tempted to include in a CBA less direct effects, variously termed 'indirect effects', 'secondary effects' and 'transmitted effects', possibly because of their prominence in the public psyche. A common example is the expected increase in property prices in areas near a new road or railway. The creation of additional jobs due to a project is another impact that is invariably emphasised at the political level.

In the case of a new or improved road or railway, the primary benefit is the reduction in travel cost experienced by existing and new users of the transport route. The benefit may be due to reduced travel time if the route is shorter, or if it is upgraded to permit faster travel. Fuel savings may also be reaped, representing a resource saving. Safety improvements can reduce mortality from crashes.

An increase in property prices is not a separate effect; it simply reflects the value of the primary benefit. People living near the improved road or railway will benefit from faster travel times or reduced fuel costs, so demand for those properties will increase, resulting in increased

prices. The increase in property prices is *caused* by the increased benefit of improved transport. It is not additional to it. Another way of looking at this is to consider that the gain from improved transport is distributed, or 'trickles down' to other sectors like real estate or to shops close to a train station. To include both the primary effect of time and fuel savings, as well as increased property prices, would be to double count the benefits of the project.

A second reason why it would not be appropriate to include increased property prices as a benefit of a road or railway improvement project is that the increased demand for properties close to the upgraded transport route may be offset by reduced demand for properties elsewhere. For example, those people wishing to move closer to the upgraded road or railway are likely to sell their existing, more distant residences. The price of those more distant residences is likely to fall, offsetting to some extent the increase in prices closer to the transport route. In a broad sense, there is an element of transfer or pecuniary effect, with price gains in one area being offset in another, and therefore the gains are cancelled out.

A focus on secondary or transmitted effects may be justified, however, when the primary benefits cannot easily be valued. If it were not possible, for example, to estimate travel time and fuel savings due to a road or railway upgrade, then any increase in property prices could serve as a proxy benefit value that reflects the underlying travel benefit. Similarly, if estimating the value of the additional water produced or harvested by the construction of a dam is not feasible, then the value of the resulting additional crop production could serve as a proxy measure.

Care is required in using secondary markets as proxies for primary effects. In the case of property prices, it may be difficult, if not misleading to designate a particular area as benefitting from improved transport, especially if not all the users of the upgraded road or railway live locally. And an improved railway route may reduce road congestion as an ancillary benefit. In the case of the dam, estimates of increased crop production would need to be controlled for the additional cost of fertilisers or altered rainfall patterns due to evaporation from the nearby dam. Further, increased crop production would exclude other benefits of the dam, such as recreational swimming and fishing, as well as negative ones such as the destruction of trees and animal habitats.

5.5 Is it really true that 'you can't monetise things like the environment'?

There is little dispute that it is not possible to monetise environmental services and impacts. It is therefore surprising that critics of CBA should focus on this aspect.

Economists do not attach monetary values to intangibles like environmental services and impacts. But they do seek to establish what values people place on them. The techniques for doing so are covered in most textbooks. Hedonic pricing, for example, is typically presented to explain the valuation of the negative value of noise: prices of houses near an airport can be compared with similar ones further away. The difference in price, other things being equal, is taken to reflect the willingness of people to pay to avoid the 'bad' of noise. The higher house price represents the sacrifice of other goods and services that could have been purchased instead of a house less exposed to noise.

The essence of attaching a value to an intangible environmental quantity lies in determining its opportunity cost. In a world of limited resources and goods, not all wants can be satisfied. It is generally necessary to give up something of value in exchange for another good or service. The maximum amount or value of the forgone good or service thus provides a measure of the value placed on the object that is acquired in its place. Where markets exist, so-called 'revealed preference' methods like hedonic pricing can be used.

In the absence of markets (for example, the value placed by people on the preservation of a wetland), 'stated preference' techniques like contingent valuation methods and choice modelling can be used. Choice modelling considers goods or services in the form of a 'bundle' of constituent characteristics, including price, that can be traded-off in various combinations. It is instructive that commercial firms like supermarkets employ so-called conjoint analysis, a technique similar to choice modelling, to estimate how much customers are likely to pay for a new type of good once it is placed on the shelf.

5.5.1 Choice of numeraire

It may be that critics of CBA are confused because CBA does in fact express costs and benefits in dollar values. However, monetary units are used for cognitive convenience, rather than because of any supposed myopically pecuniary worldview held by economists.

It would be conceptually feasible to measure costs and benefits in terms of alternative units of measurement, such as sea shells or cups of coffee. But dollars are preferred, simply because they are readily understood by most people. Without first translating into monetary units, most people would find it difficult to assess how many cups of coffee they would be willing to trade-off to save a koala or some threatened species. The monetary value of other goods and services that people are prepared to give up in exchange for a koala reflects their willingness to pay to save it.

5.5.2 The non-measurable

Finally, Gramlich (1981, p. 5) addresses several misconceptions about CBA, one being that:

> benefit-cost analysis is a mechanical substitute for common sense. Nothing could be further from the truth. Benefit-cost analysis is really a framework for organizing thoughts, for listing all pros and cons, and for placing a value on each consideration … in the real world there will be some considerations that cannot easily be enumerated or valued … the sensible way to deal with such omitted considerations is not to abandon all efforts … but rather to … quantify what can be quantified, to array and rank nonquantifiable factors, and then to make a decision.

5.6 Can benefits be measured as 'costs (or damage) avoided'?

It is not uncommon to see CBA studies estimating benefits in terms of the damage cost averted, invariably in financial terms. The practice is particularly prevalent in disaster situations and in climate change modelling. The 'costs avoided' approach is also sometimes presented as the 'defensive expenditures method' (e.g. Boardman et al., 2011,

ch. 14). It appeals particularly to those who perceive costs and benefits in terms of production function effects. However, the outcome is essentially a cost–cost study, rather than a conceptually ideal CBA.

Flood mitigation benefits are often estimated in terms of the damage avoided. Such estimates tend to focus on the financial cost of replacing or repairing damage to houses, furniture, and infrastructure. They therefore exclude the more subjective value placed by people on items such as family photographs or heirlooms that may have been destroyed and are an underestimate of the likely willingness of residents to pay to avoid a flood event.

Studies of droughts (climate-induced or not), often combined with appraisals of constructing dams, may well overestimate benefits by taking a production-oriented approach. Such studies tend to take as a given the current level of production of a specific crop. A disaster is then assumed to fully destroy the crop, possibly in perpetuity in the case of a climate change effect. Avoiding the total cost of the fully destroyed crop is counted as the potential benefit.

In reality, farmers might not sow a crop in a bad year, saving on seed, fertiliser and other inputs and/or engaging in off-farm employment, or they may substitute a less water-dependent crop. That is, farmers are in reality more likely to adapt to changing conditions rather than continuing to plant their usual crop each year, and waiting passively for it to be destroyed. Benefits estimated as the avoided cost of fully destroyed crops into the future are thus likely to be overestimates.

An example provided by Boardman et al. (2011, ch. 14) is that of a smoggy city where residents periodically hire workers to clean their windows. This 'defensive expenditure' can be used as an estimate of the cost of mitigating or eliminating the negative externality. Avoidance of part or all of this expenditure can be considered to be a measure of the benefit of a policy that reduces the amount of smog. To the extent that 'smog also leads to dirtier shirts and to health problems', the window-cleaning approach will result in an underestimate of the benefit of cleaner air. Hanley and Barbier (2009, ch. 6) point out that modern production function approaches seek to estimate the effect of environmental changes on consumer and producer surplus in response to changes in costs and prices of the final marketed good.

Mishan (1988, ch. 3) refers to an apparently popular practice of estimating the benefit of reducing or eliminating a disease using a 'costs avoided' approach. The approach includes three separate categories:

- expenditures on medical care, including the costs of the services of physicians and other medical personnel, drugs, hospital facilities and equipment
- loss of production, measured in terms of loss of earnings
- pain and discomfort, although this area cannot be measured directly.

Mishan's judgement about the approach is worth quoting in full:

> The … [averted costs] … method of calculating the benefits of eliminating a disease cannot strictly be justified by reference to economic principle. A reduction in cost can be directly translated into a benefit for society only when — as in an increment of consumer surplus from a fall in price — we are operating on the demand curve for a specific good. If, for example, the good in question were a standardized health unit which could be purchased on the market, and the unit cost fell by an amount that resulted in a saving of $5 billion a year for the same number of health units bought, then the benefit would indeed be equal to the cost saving of $5 billion a year.

To some extent popular use of the 'damage costs avoided' approach is understandable, because costs are generally easier to estimate than benefits. However, when 'stakeholders' (typically vested interests) are able to marshal political support by producing dramatic anecdotal material or egregious cost estimates, the well-being of the community can suffer. A significant increase in expenditure on a familiar ailment, such as arthritis, may 'crowd out' the introduction of a new, but hitherto unknown cancer drug. It is therefore important to compare alternatives on the basis of additional expenditure and additional benefits rather than just total costs avoided (see Section 5.6).

For some variables, it may be apposite to determine associated dose-response relationships: for example critical concentration levels of specific nutrients in rivers that will cause algal blooms (Read Sturgess, 2000), or vehicle operating costs per kilometre at different speeds (Tan et. al., 2012). A pertinent example is a study by Ludwig et al. (2009), who modelled the effect of a large decline in rainfall on a number

of sites in the Western Australian wheat belt. Simulations indicated that not only did crop yields *not* fall, but leaching of fertiliser also decreased, thus reducing costs to farmers, and the spread of dryland salinity was reduced significantly. Further, beneficial profit outcomes were obtained through minor variations in planting periods for two wheat varieties.

5.7 Conjuring up the benefits of jobs — 'it's not what you see, it's what you don't see'

In highlighting job creation as a social benefit of a pet infrastructure project, politicians bear a considerable affinity to magicians. By drawing the attention of the audience to the obvious job-creating effects of a project or policy, they are able to neglect consideration of corresponding, but less visible losses in employment or social well-being.

An oft-cited example of the job-creation fallacy is the 'broken window' allegory by Frederic Bastiat (1850), who distinguished 'between a good and a bad economist [on the basis that] … the one takes account of the visible effect; the other takes account both of the effects which are seen, and also those which it is necessary to foresee'. In effect, Bastiat draws attention to the need to take opportunity costs into account.

Bastiat (1850) posits an angry shopkeeper whose careless son has just broken one of the shop windows. As an inquisitive throng of shoppers mills around the scene commiserating with the shopkeeper, one bystander offers the consolation that 'everybody must live, and what would become of the glaziers if panes of glass were never broken?'. Bastiat points out that this is to focus on the obvious and immediately visible consequence, to the exclusion of other effects. It presupposes that the shopkeeper pays an amount of, say, six francs to the glazier. The shopkeeper gains a good — a new window pane — that he values at six francs, and the glazier gains an equal amount of six francs; so society as a whole is no better or worse off than before.

It is only by taking into account a wider perspective of the whole of society that one appreciates the fallacy, points out Bastiat. Had the window not been broken, the shopkeeper might have fulfilled his original desire to buy a pair of new shoes. One needs to take into

account all other third parties, like the shoemaker, or some other tradesman, who suffer by the loss of their potential sale. In other words, the additional employment of the glazier is exactly offset by the forgone opportunity of employment of the shoemaker or some other tradesman. There is no net offsetting gain in employment to society, which simply loses the asset of a previously existing window.

5.7.1 Two less immediately discernible effects that merit consideration

It is not clear why people — even those with some training in economics — are willing to be side-tracked by claims of 'more jobs' as an indicator of social benefit of a project or policy, without considering the wider impacts. Lakoff and Johnson (2003, ch. 13) argue that metaphors such as 'labour is a resource' and 'time is a resource' reflect cultural values about work and the ability to quantify labour. These perspectives even induce a notion of 'leisure time' as a resource not to be wasted, with a whole industry devoted to ensuring that it is used productively. It is also possible that wider public awareness of Keynesian economics has engendered an unwarranted view of government expenditure and employment creation as being 'good things' in themselves and in all situations.

Whatever the reason for the apparent allure of job creation, there are two broad, less visible issues that merit consideration in any claimed job creation benefits. The first of these is analogous to the fallacy identified by Bastiat (1850).

First, while project proponents are keen to emphasise as many job creation impacts of a project as they can, it is rare to see discussion of any countervailing deadweight loss to society due to the funding of the project (Appendix 7). If a major project is unambiguously funded by increased taxation, the aggregate level of both consumption and savings in the economy are likely to fall because people's disposable income is reduced. A reduction in consumption levels, and reduced investment due to reduced savings, will reduce overall economic activity, and consequently employment levels. However, this negative effect on employment levels may be partially offset by an increased desire by some individuals to work more, in order to recoup their loss in disposable income.

An alternative would be for the government to borrow the funds required to finance a project. Whether the funds are borrowed domestically or overseas, they eventually need to be repaid, most likely through increased taxes at some future time. The 19th-century economist David Ricardo argued that public borrowing would be perceived by rational citizens as being a precursor to increased future taxation, and they would therefore curb their consumption from the outset in anticipation. Although not uncontroversial, this concept of 'Ricardian equivalence' is argued to result in reduced consumption due to public borrowing in the same trajectory that would be observed in a scenario of increased taxation at the time of project implementation.

An alternative that involves neither increased taxation nor borrowing is to reduce current government expenditure in other areas of the economy, for example on education or defence. In this case, the social cost of tax financing becomes irrelevant. While this would avoid the problems of deadweight loss and Ricardian equivalence, it would also have a direct, negative effect on employment in those areas where cutbacks occur.

A second issue that requires consideration is the source of the additional labour that is employed on a new project. For example, the government of the Australian Capital Territory (ACT) in October 2014 called for expressions of interest to build and operate a light rail system to connect the north of Canberra with the city centre. A key supporting argument for the project was that it would increase employment opportunities in the ACT. Although the 'standing' or perspective taken by the business case was not specified, the proposition of increased employment opportunities does not necessarily translate into more jobs for Canberra residents. Nor was it explained why the objective of more jobs should be fulfilled by construction of a light rail system — employment could also have been increased by building more hospitals or schools, or even by digging and refilling holes.

In a situation of reasonably full employment in the ACT economy, a Canberra resident employed in the ACT who takes up a newly created position on the light rail system will not increase the total level of employment in the ACT. The net effect will simply be a transfer of employment from one occupation to another within the ACT. Indeed, in a situation of full employment, the vacated position is more likely to

be filled by someone from outside the ACT. In this case, the net effect is that the number of Canberrans employed as a result of the project will not change, despite the increase in job vacancies created.

If the vacated position cannot be filled even by workers from outside the ACT because of high employment levels across Australia, there may even be some offsetting loss in production in the ACT. An increase in the wages offered could attract outside workers, but the increased cost of labour may also force some ACT businesses to cease production and hence reduce employment opportunities within the ACT. This reduction will offset some of the additional jobs created by the light rail project.

In a situation of frictional or less than full employment in the ACT economy, it will be possible for at least some Canberrans to accept a position on the light rail system, assuming that they have the requisite skills, or can acquire them on the job. The individual worker will gain the benefit of a wage — including tax that is gained by the Federal government — that exactly offsets the cost to the employer (the so-called 'equilibrium assumption': Mannix, 2013). However, there will be an additional loss to Canberra society because of the individual worker's loss of leisure time on taking up employment.

Leisure time is another of those commonly 'not seen' effects of job creation where previously unemployed workers choose to work. Defined variously as 'non-paid work time' or simply 'non-work time', leisure can include anything from doing absolutely nothing, sleeping, minding children, gardening, or listening to music. All of these are economic benefits, despite the fact that they may not result in the production of marketed goods or services. Depending on an individual's preferences, each item contributes to their personal utility, and hence to the overall well-being of the society to which the individual belongs. Because employment necessarily results in the loss of some leisure, its loss represents an opportunity cost to a previously unemployed individual, and hence to society.

Other issues that might be considered in a detailed CBA would be the transaction costs of a worker changing employment or taking up a job when previously unemployed. Transaction costs could include new clothing, travel costs, possible residential relocation costs, or childminding costs. Employers, too, face additional costs in interviewing job applicants, training new workers, placing vacancy advertisements, and loss of productivity due to errors made by new workers.

5.7.2 How to accommodate politicians' perspectives?

In general, it would be conceptually difficult to argue that job creation in itself generates social benefits. It might, however, be argued that there is some form of 'existence value' gained by people who are happy that unemployed residents have been able to find paid work. If it is accepted that higher employment levels are associated with reduced crime, and causation can be demonstrated, then there may also be a wider social benefit of increased employment levels. Attribution of any of these benefits would, however, require direct evidence of their existence, and some form of measuring their magnitude. Adler (2013), for example, argues that research is required into the nexus between unemployment and physical and psychological health and its monetary equivalent.

Nevertheless decision-makers at the political level invariably require information on the employment impacts of a project or policy. Some Australian jurisdictions accommodate this requirement by providing a separate brief, or a separate section following a CBA, that provides information on likely job creation. This approach satisfies the need to provide employment impacts, without compromising the integrity of the CBA by including job creation as a benefit in calculations, or in presentation.

5.8 True or false?: Taxes are just transfer payments, so they can be disregarded

It is true that a tax collected (or subsidy provided) by government is a transfer payment.[3] Taxes in themselves do not constitute a social benefit or a social cost. Analogous to a voluntary charity donation, a tax is simply a transfer from taxpayers to government. Subsidies involve transfers from government to a particular segment of society.

3 A transfer payment differs from a normal market transaction in that resources are transferred from one party to a second party, but nothing is provided in return by the second party to the first.

Nevertheless, taxes, and their obverse, subsidies, represent economic distortions that create differences between prices paid by producers and consumers for a particular good or service. It is therefore important in estimating the social cost or social benefit of goods or services to take into account the taxes and subsidies that apply to them.

The subject of adjusting market prices for taxes and subsidies is not always entirely straightforward. Sinden and Thampapillai (1995, p. 50) whimsically provide a guideline to the effect that 'Taxes and subsidies should sometimes be included, and sometimes be excluded'.

Prices adjusted for taxes and subsidies are typically referred to as 'shadow prices'.[4]

The concept of willingness to pay (WTP) can be used to determine how benefits (outputs) should be adjusted for taxes and subsidies. Opportunity cost can be used to adjust the costs of inputs. In each case it is important to also identify whether a project results in an increase in outputs or inputs, or whether it displaces the quantity of existing inputs or outputs in the market. Table 5.6 provides a broad categorisation.

Table 5.6: Adjusting for taxes levied (and subsidies provided) on inputs and outputs

Supply/demand	Increase in availability	Displacement or diversion of existing units
Outputs	**A** Market price, including taxes less subsidies, to reflect willingness to pay to acquire the output.	**B** Market price plus subsidies less taxes. The benefit is the value of the units saved by not producing the existing units of output.
Inputs	**C** Market price less taxes plus subsidies. The benefit is the resource (opportunity) cost of the additional inputs.	**D** Market price, including taxes less subsidies, to reflect productivity in previous use.

Source: adapted from Department of Finance (1991), Department of Finance and Administration (2006), and Sinden and Thampapillai (1995)

4 Boardman et al. (2011, ch. 4) describe shadow pricing as a means of assigning benefit or cost measures 'when observed prices fail to reflect the true social value of a good accurately or observed prices do not exist … thereby finding "in the shadows" needed values that are not readily observable'. It is also useful to note that shadow prices used in CBA are not the same concept as the one used in linear programming.

Quadrant A represents an increase in availability of an output, which would be valued at the market price. For example an increase in the supply of water from a newly constructed dam should be valued on the basis of farmers' willingness to pay for it; that is, the market price inclusive of taxes but excluding any subsidies. At least some of the dam water would have previously formed part of the flow of a river and has now been diverted to agricultural use (quadrant B). It is therefore likely to have displaced the benefits of recreational use by people swimming or fishing in the river that has now been dammed. In other words, part of the benefit to farmers is gained at the expense of the output of water (a benefit) that is no longer available to recreational users. The benefit that is diverted from (lost to) recreational users to farmers is the resource value that is 'saved' by reducing recreational use and would therefore exclude taxes. Determining the resource cost of the river water, however, may be problematic.

Shadow pricing the cost of inputs depends on whether there is an increase in availability of the input (quadrant C), or whether existing uses of the input are diverted (quadrant D) to the new project. The value of additional inputs is determined by the opportunity cost of the resources. An example is the employment of additional workers who were previously unemployed: the cost of these additional workers is the opportunity cost of the loss of their leisure time. The use on a project of workers already employed elsewhere is the opportunity cost of the marginal revenue product that they would have generated in their previous employment had they not been displaced: reflected in the wage — including income and payroll tax minus any subsidies — their previous employer was willing to pay them.

Perkins (1994, ch. 7) provides a range of further examples for both distorted and undistorted markets of the Harberger approach to estimating shadow prices, including relevant formulae. The Harberger approach involves calculation of weighted averages of increased outputs or inputs and the corresponding amounts that are displaced or diverted. As might be expected, economic benefits and costs depend on the relative elasticities of demand and supply, changes in quantities and prices, and the presence of taxes and subsidies. However, the Department of Finance and Administration (2006, s. 3.5) points out that it is not uncommon for project demand for inputs to be relatively

small compared to total production, and the price elasticity of demand is usually large ('flat' demand curve), so that shadow prices 'will be close to the market price and this sort of analysis is unnecessary'.

5.8.1 Correctional (Pigovian) taxes

One purpose of taxation is to raise revenue. An alternative rationale for levying taxes is to encourage or discourage consumption or production of goods and services.

However, the distinction may not always be clear cut. Campbell & Brown (2003, p. 111) pose the question whether a tax on tobacco is intended to raise revenue because of its inelastic demand, or whether it is a correctional tax intended to reduce consumption to avoid imposing costs on the health system. In assessing this distinction, a degree of judgement is required on the part of the analyst conducting the CBA.

Corrective taxes[5] or charges imposed unambiguously to reduce negative externalities, such as traffic congestion, should be set to reflect the additional cost imposed by each driver on other car drivers. By not taking into account (internalising) the cost imposed on others, drivers demand an increased amount of output in the form of additional trips. The corrective tax is intended to reduce the demand for road trips to a socially optimal level, by equating the marginal benefit to the marginal social cost. Imposition of the corrective tax therefore diverts resources that would otherwise have been used for car travel to other uses. However, the correct shadow price of road usage should include the corrective tax, in contrast to the approach of excluding a purely revenue tax in Table 2.8 for a diversion or displacement of existing outputs.

A subsidy on diesel used by farmers will see farmers paying a lower price than the market price paid by other users at the bowser. If the government reduces distance travelled by building new wheat silos closer to farms, farmers will save on fuel. Campbell & Brown (2003, ch. 5) point out that value of the fuel saving should be calculated on

5 Sometimes called Pigovian taxes after AC Pigou (1920, Vol. 1, ch. 9), who proposed the imposition of compensatory payments on private individuals who produce negative externalities to reflect social costs of production.

the basis of the market price because it reflects the cost of production. In other words, the subsidy needs to be removed from the price paid by farmers in order to obtain the resource cost.

5.8.2 Marginal excess tax burden (deadweight loss due to taxation)

When a project is funded through increased taxation, the level of economic activity will be reduced because of the negative effect on consumption and/or investment. The resulting loss of social surplus is a deadweight loss. Appendix 7 deals with this issue.

5.8.3 Discount rates

Harberger (1976, ch. 2) argues in favour of the investment-oriented social opportunity cost of capital over the consumption-oriented social rate of time preference for discounting, but emphasises the need to adjust private returns for taxes. The argument is analogous to including taxes when considering the value of additional production or diverted use of inputs in Table 5.6 above. Part of any additional product is skimmed off by government in the form of taxes:

> There are a number of possible sources of divergence between the social and private benefits of private investment; but of these, by far the most important consists of taxes … Of two investments with the same private yield, one of which generates corporation income tax payments equal to its private yield, and the other of which generates no tax payments at all, the former is clearly socially preferable, as it either enables the public sector to have more command over real goods and services or, alternatively, it permits the public sector to reduce some other tax and thus permits the private sector to buy more real goods and services. The indicated procedure is therefore to include corporation tax payments generated in any industry as part of the social return to capital in that industry. And if the social rate of return to capital is estimated for the private sector as a whole, the entire yield of the corporation income tax should be added to the income perceived by private enterprises in order to convert the latter to a social concept of 'income generated by capital'.
>
> Where indirect taxes exist on a final product, they lead to a situation in which the value of the marginal product of each factor of production involved in that good's production exceeds the income earned by

> that factor by the percentage rate of indirect tax. In this case, the income from capital (gross of corporation tax) should be augmented by a fraction of the receipts from the indirect tax, the fraction being capital's share in the value added in the industry in question.

Harrison (2010) explores in more detail tax adjustments from the perspective of discount rates.

5.9 Another misconception: Sensitivity analysis should be used to adjust for risk in a CBA

Sensitivity analysis is distinct from the adjustment of costs and benefits for risk. It is specifically directed at ascertaining how the NPV of a project would change if the magnitude of one of the variables included in the calculation was altered.

5.9.1 Adjustment for risk

To aggregate costs or benefits requires that they be expressed in commensurate units or 'dimensions'. Values are routinely adjusted for inflation by conversion to real values, and for time by discounting. Adjustment for risk is also worthwhile because receipt of a risky dollar is unlikely to be valued in the same way as the certain receipt of an identical amount: a bird in the hand is invariably worth two in the bush.

Following Knight (2009 [1921]), risk is generally conceptualised as variation from a measure of central tendency, such as the mean. It therefore requires knowledge of the associated probabilities of events — such as the size of a benefit, or timing of a cost — occurring. Adjustment for risk can be carried out by calculating expected values in the form of probability weighted averages. An extension of this approach is to employ decision trees and to attach probabilities to different scenarios. Boardman et al. (2011, ch. 7) provide an exposition of both expected values and analysis using decision trees.

Monte Carlo analysis offers a more sophisticated form of risk analysis, but requires specification of associated probability distributions, rather than single-point estimates of probabilities of occurrence.

Repeated random sampling from the probability density functions attached to the variables included in estimating the CBA generates a probability distribution of possible NPV, rather than producing a single-point estimate of the NPV. Software such as @RISK (www.palisade.com/risk/) allows straightforward application of the Monte Carlo method.

5.9.2 Sensitivity analysis

Despite a common misconception, sensitivity analysis is *not* a form of risk analysis; nor is it a substitute for risk analysis. Risk analysis requires the application of probabilities to input variables. Sensitivity analysis can be carried out whether or not risk analysis has been undertaken. Its primary objective is to discover the extent to which each of the constituent variables of the CBA influences the final result, the calculation of NPV. Some analysts also vary input variables to determine 'break-even', 'switch-over', or output 'switching points', such as the point when NPV becomes zero or changes sign.

Sensitivity analysis can be carried out simply by changing the value of one variable at a time, or even several or all the variables together. Some sensitivity analyses choose 'worst case' and/or 'best case' values. Alternatively, it is possible to use an absolute or percentage variation either side of the input variable values used in the calculation of the NPV, although Perkins (1994, s. 15.7.2) points out that comparability of the sensitivity of NPV to different input variables should be based on equivalent variations, such as one standard deviation from the mean. Software like @RISK produces a sensitivity analysis of the Monte Carlo result in the form of a tornado chart. That is, sensitivity analysis can, and should be applied after any adjustment of input variables for risk.

In the case where a change in the value of a particular input variable exhibits a substantial influence on the calculation of NPV, sensitivity analysis provides a valuable signal. If the analyst is not fully confident that the value of that particular input variable has been robustly estimated, then it would be prudent to revisit the estimation method to ensure that the variable value is as accurate as possible. If the estimation cannot be improved, then the CBA report should draw the decision-maker's attention to the fact that a particular variable is influential in determining the NPV, but its value may benefit from improved estimation.

Where an NPV has been estimated as a probability distribution on the basis of risk analysis, sensitivity testing can be applied in a more sophisticated form than mere absolute or percentage deviations from estimated values of input variables. Software such as @RISK can also be used to vary the parameters of the probability density functions that have been used to define the risk attached to each input variable. In other words, advanced sensitivity analysis can involve not only the most plausible or expected value of each input variable (the first moment of the distribution), but also its variance (the second moment of the distribution) and the degree and direction of skewness (the third moment).

5.10 Confusing marginal and average: Does a positive mid-term economic appraisal indicate that a program should continue, or be expanded?

A CBA is typically carried out before a project is implemented (and ideally before a decision is made to implement it). This ex ante approach is (less frequently) supplemented by an ex post appraisal, after finalisation of the project. It is much rarer still for a mid-term (*in media res*) evaluation to be carried out.

A particular advantage of a mid-term CBA evaluation, perhaps as part of an implementation review of a project, is that it offers the option of terminating or expanding the project, as well as simply continuing it as originally envisaged. An example of a mid-term review is the evaluation of the Australian Government's Rural Transaction Centres program (Dobes, 2007). The CBA found that the provision of a range of government and commercial services to about 50 smaller regional towns was socially beneficial.

It can be tempting, but wrong, to consider a positive NPV result obtained from a mid-term review to be an indication that an expansion of the project or program would consequentially also be socially beneficial. The fallacy here of course is that the mid-term review will estimate an NPV based on the average results of the project. However, an expansion of the project or program requires consideration of all *additional* costs and *additional* benefits attributable to the expansion.

The base case is no longer the original 'do minimum' counterfactual, but rather the project that has already been (partially) implemented. Any attempt to carry out the CBA simply for an expanded project against the original counterfactual would be misguided, even if the overall result still produced a positive NPV.

The distinction between average and marginal results is also important in the case of inputs accounted for in a CBA, whether ex ante, ex post, or *in media res*. It is often the case that average values are used because market prices can be readily observed. A large project that draws heavily on a particular input (e.g. concrete, or highly specialised workers), however, may see an increase in cost. It is the increased cost that should be used in the CBA, not the average price that exists before the project is implemented.

The distinction between marginal and average values of benefits is equally important. The Washington State Institute for Public Policy (2014, p. 172) puts it well:

> One important concept for long term portfolio analysis is that of diminishing returns. This is the precept that, as a program serves more and more of its eligible population (that is, as it reaches market saturation), the effectiveness of the program for each new participant may be reduced.

The Rural Transaction Centres program analysed in Dobes (2007) provides a concrete example. At the outset of the program, smaller towns that are distant from regional centres were provided with government assistance. As the number of assisted towns grew, it was inevitable that the additional towns receiving assistance would be larger and closer to regional centres. Because a key determinant of benefits was the generalised cost of transport between the assisted town and a proximate regional centre, the additional benefit to the overall program contributed by each extra town would be lower. At some point, further expansion of the program would be ineffective, once additional costs outweighed the additional benefits.

Finally, choice modelling (see s. 5.5 above) has the useful attribute of yielding estimates of the additional WTP if one or more characteristics of a good or service are increased. CVMs, on the other hand, are generally restricted to estimating a single WTP value for a good or service. In terms of estimating the benefit of program expansion, therefore, choice modelling has an advantage over the CVM approach.

This text is taken from *Social Cost-Benefit Analysis in Australia and New Zealand: The State of Current Practice and What Needs to be Done*, by Leo Dobes, Joanne Leung and George Argyrous, published 2016 by ANU Press, The Australian National University, Canberra, Australia.