

Guide to Social Cost Benefit Analysis

July 2015



New Zealand Government

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Foreword

Anybody can make decisions. But if the decision involves other people's money, then it behoves us to think about the impacts on them. This is much harder than to think about the impacts on ourselves.

One thing that is dear to my heart, both as a citizen and as a public servant, is to improve government decision-making. Good decision-making means good government. To be able to make good decisions, we need to be well informed about how the decisions impact on people.

But many government decisions are about matters that have very complex and varied consequences. Ministers – in fact anyone who makes significant decisions - need help in obtaining and organising information in a way that helps decision-making.

This is where cost benefit analysis comes in. Cost benefit analysis is first and foremost an organising principle. It is a way of organising information in a consistent and systematic way. It is about making best use of whatever information is available.

It is about evidence-based policy development.

This guide is called 'social' cost benefit analysis because at its most basic, a cost benefit analysis that the Government is interested in must identify all the economic (including social and environmental) impacts of decisions on people, whether or not they can be quantified.

But comparison of different alternatives is not possible unless decision-makers form a view about the relative size of the various impacts.

Fortunately, the cost benefit analysis literature has developed a tool-box of techniques for helping decision-makers with the sizing problem.

This guide is not a comprehensive textbook or manual for teaching those techniques. It has three main purposes: to outline the main steps and organising principles that advisors to decision-makers should adopt, to give project managers a sense of what they can expect from cost benefit analysts, and to provide analysts who carry out cost benefit analysis with guidance on some short-cuts, or standard values that will generally be acceptable for inclusion in their analysis.

I commend this guide to all those who are interested in better decision-making.

For myself, I will always expect to see a cost benefit analysis (CBA) when the Government is being asked to make a significant decision.

A handwritten signature in black ink, appearing to read 'G. Makhlouf', with a horizontal line underneath.

Gabriel Makhlouf
Secretary to the Treasury

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Introduction

- Significant decisions should be accompanied by some kind of CBA.
- A rough CBA is better than no CBA.
- A CBA is primarily about organising available information in a logical and methodical way.
- A CBA measures the impact of a decision on the public at large. It should attempt to be value-free. Different methods should be used to measure the extent to which a proposal fits with decision-makers' objectives and policies.

1. All decisions require some kind of formal or informal CBA. The main purpose of this guide is to encourage all decisions to be accompanied by at least a rough CBA, on the grounds that it is likely to be better than decision-making based on prejudice or instinct. But it should also encourage doing a more comprehensive CBA where the importance of the decision warrants it. This might entail employing specialists where an agency doesn't have the necessary skills or resources in-house.

2. CBA is often rejected on the grounds that some benefits are hard to measure. While that is often true, a CBA is about organising in a logical and methodical way whatever information is available. And some information is always available. As this document will demonstrate, the purpose of CBA is not to calculate "the" benefits and "the" costs, but to reduce the degree of uncertainty that would otherwise exist around benefit estimates. There are a number of techniques for doing that. Without these, decision-makers would be left to rely on their own intuitions only, or worse, on the intuitions and prejudices of their advisors.

3. To emphasise this point, it is worth reflecting on the difficulty of intuitively estimating the total value of benefits that are spread across a large number of people, let alone comparing that value with a cost that may be in the tens of millions or even in the billions of dollars. These are sums that most of us have little experience with in our personal lives and find very hard to comprehend at an intuitive level. Systematic methods are therefore required for comparing the benefits and costs with each other.

4. A systematic method doesn't necessarily need to be complex, detailed and expensive. Even a rough, back-of-the-envelope calculation can be logical and methodical. And as will be apparent from this guide, more can be measured than people often assume. A rough calculation may be a first approximation and may be better than nothing. If nothing else, it will give an indication of what is at stake and will help decide whether a more detailed CBA should be undertaken. Appendix 2 provides a worked example of a rough CBA.

5. The following are some points that are worth making at the outset:

- When doing a CBA it is important to be mindful of what we are measuring. Government sector decision-makers need two kinds of information, which need to be analysed separately:
 - The extent to which a proposal fits with their objectives or policies. The answer is sometimes obvious, but if it is not then some kind of analysis may be required. A multi-criteria analysis (MCA) often lends itself to this.

- How the decision impacts on the public at large. This is the domain of CBA. A CBA should be free of ethical or policy considerations¹.
- An important feature of decision-making is that the economic impacts, i.e. the costs and the benefits, generally lie in the future. CBA is therefore a forecasting exercise. This has some important implications:
 - There is uncertainty around all estimates of future costs and benefits. The degree of uncertainty can be revealed by using ranges rather than point estimates.
 - The degree of uncertainty can be reduced by undertaking research. But this has a cost, so the question of how much research to undertake needs itself to be subjected to some kind of CBA.
 - Because costs and benefits are usually forecast to arise in different time periods and are often spread over a number of years, there is a need to reduce them to a single measure so they can be compared with each other. This can be accomplished by discounting them to a common point in time.
- Costs and benefits can only be compared if they are expressed in the same measurement units. Money values are the most convenient for this purpose. While some costs or benefits are difficult to measure in money terms, economists have developed a number of techniques to indirectly infer their value in money terms.
- One consequence of measuring costs and benefits in money terms is that it doesn't take into account the fact that money itself is worth more to some people than to others. Such 'equity' issues are difficult for CBA to take into account. However, they shouldn't be ignored. This guide therefore recommends that equity or distributional consequences of decisions should be drawn to the attention of decision makers at the same time as providing information on the CBA.

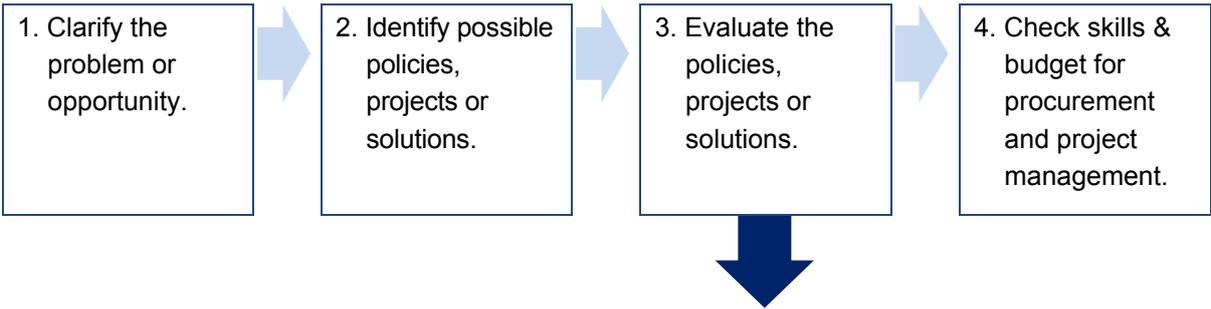
¹ This is not to deny that analysts' perceptions are inevitably distorted by their own values. It is merely saying that when measuring the impact on the public, the endeavour should be to put one's own values or the values of decision-makers aside as far as possible, to the extent we are aware of them.

Part 1: Guide to Cost Benefit Analysis

6. This page outlines how CBA fits into the generic policy development process, what its main steps are and where in this guide you can find more information on each.

7. Specific policy development processes, such as the process for developing regulations or for developing a business case, may be expressed slightly differently but they have the same core elements. They all involve some form of cost benefit analysis, as outlined below:

The Policy Development Process



Policy evaluation (the CBA)

The following are the main steps:

- Step 1:** Define policy alternatives and counterfactual (see page 9)
- Step 2:** Identify the people who gain and those who lose (see page 10)
- Step 3:** Identify the benefits and costs; allocate to time periods (see page 12)
- Step 4:** Quantify the benefits and costs within ranges (see page 16)
- Step 5:** Discount to a common period, compare benefits with costs (see page 33)
- Step 6:** Is the result clear enough? If not, consider whether it is worth investing in more research, and repeat above steps (see page 39)
- Step 7:** Write report (see page 40)

Step 1: Define policy and counterfactual

- The economic impact of a policy or project is measured against a “no decision” counterfactual. It is important to be clear as to what the counterfactual is.

8. Any policy or business process starts with defining a problem or opportunity and identifying the potential need for a project or regulatory proposal. This might be done, for example, in the context of the Strategic Assessment stage of the Better Business Case process. See page 44.

9. Having established the potential need for a policy, the next thing to do is to clearly define the policy, alternative solutions and the counterfactual. The counterfactual is the situation that would exist if the decision is not made, if the policy does not go ahead. It is sometimes described as the “do nothing” or as the “do minimum” scenario. It is important to characterise the counterfactual accurately and to use it consistently, as the benefits and costs of the policy alternatives are measured against the counterfactual. This is often not straightforward, in particular where the “do nothing” or the “do minimum” scenarios are likely to evolve over the evaluation period. In those situations it will be necessary to forecast the evolution of behaviour and technologies.

Example: Bridge over river

Suppose that the bridge costs \$20 million, and that it will save travellers \$25 million worth of travel time and vehicle operating costs, in present value terms. The bridge would appear to have benefits that exceed the costs. The net present value (NPV) of the bridge is \$5 million.

But suppose that in the absence of a bridge being built, there is every expectation that a private ferry operator will start business. The cost is \$10 million in present value terms, and the social benefits are \$20 million in present value terms. The ferry operation has an NPV of \$10 million.

Compared with the ferry operation, a bridge would cost \$10 million more, and would produce \$5 million more benefits. Against this counterfactual, the bridge has an NPV of –\$5 million.

Against the “no bridge, no ferry” counterfactual, the bridge would seem worthwhile. But against the “ferry” counterfactual, the bridge is not.

Equivalently, the ferry could be presented to decision-makers as an alternative to the bridge. This would still show the ferry to be the better option, despite the fact that the bridge has greater total benefits.

10. As the example above suggests, it is good practice to consider several alternative options for solving a problem or achieving an objective. Each of these should be treated as a separate policy to be evaluated against the counterfactual.

11. Finding the best alternatives is an art rather than a science. It relies on creativity and innovative thinking, and should include the best from an economic perspective even if they are not consistent with decision-makers’ objectives. It is important for decision-makers to know what alternative policies or solutions they are rejecting.

12. Whether a policy is a good one is often not known until the CBA has been carried out. In such cases, and where an apparently good option is found to be not good, it may be necessary to go back to the first step and define and analyse additional alternatives.

Step 2: Identify who gains and who loses

- All people in New Zealand affected by a policy should be recognised in the analysis.

13. Before identifying costs and benefits, it is useful to identify the people who are affected by a decision and whose costs and benefits should be taken into account in the CBA.

14. This guide is about undertaking a CBA from a national perspective rather than a government or departmental perspective. An analysis from a departmental perspective is termed a 'financial analysis' or 'financial CBA' and is described further below.

15. An analysis from a national perspective, often termed 'economic Cost Benefit Analysis', or 'social Cost Benefit Analysis', is preferred because the actions of one agency or department can impose costs or benefits on individuals or the nation as a whole (eg, increasing the size of a programme operated by a particular department may assist the operation of the department but may nonetheless require a large increase in income tax on individuals). The analysis should therefore look through entities, such as the government, to the people that are affected by decisions.

16. All people in New Zealand affected by a policy should be recognised in the analysis. This includes people in their role as taxpayers. However, there are situations where the definition of who is a gainer or loser is not straight-forward. Some of these are described here:

- While in principle the focus should be on those ultimately affected rather than on intermediaries, there may be good grounds for believing that the impact on intermediaries is a reasonable proxy for the former. For example, a better road link that reduces transport costs may benefit a manufacturing company, but where there is competition, most or all of the benefit is likely to be passed on to consumers in the form of lower prices. The workers or shareholders of the manufacturing company may therefore not benefit themselves from the better road link, but the reduction in transport costs enjoyed by the company is a reasonable proxy for the impact on the final consumers (however, see discussion on primary and secondary markets on page 19).
- Government sector CBAs are intended to measure the benefit to people in New Zealand. This means that benefits or costs that accrue to people outside New Zealand are generally ignored, on the grounds that the government only has responsibility for the well-being of those who are in New Zealand.
- Future generations: the current generation has the prerogative to make decisions that could affect the welfare of future generations. The current generation may care about the welfare of future generations, but this is expressed through the current generation's willingness to pay. This needs to be measured empirically or through the political process. There is little justification for an analyst to override the preferences of the current generation. Nor can an analyst predict the preferences of a future generation.

Transfer payments

17. It is usual practice to ignore gainers and losers who are parties to transfer payments, such as taxes, subsidies and welfare payments. This is merely for convenience, because the benefits to the recipients are assumed to offset the costs to the payers. The cash component of a transfer does not involve the creation or destruction of resources.

18. However, transfer payments usually have incentive effects and the welfare impacts of these should be taken into account. For example, if a welfare payment scheme induces a person to work less than the person would otherwise choose to, then there is an income loss that should be taken into account. This 'deadweight cost' is discussed on page 15.

Contrast with financial analysis and fiscal costings

19. An economic CBA needs to be distinguished from a financial CBA as well as from the fiscal costings which typically are included in a Cabinet or other approval paper. The key differences between the different types/levels of analysis are summarised below:

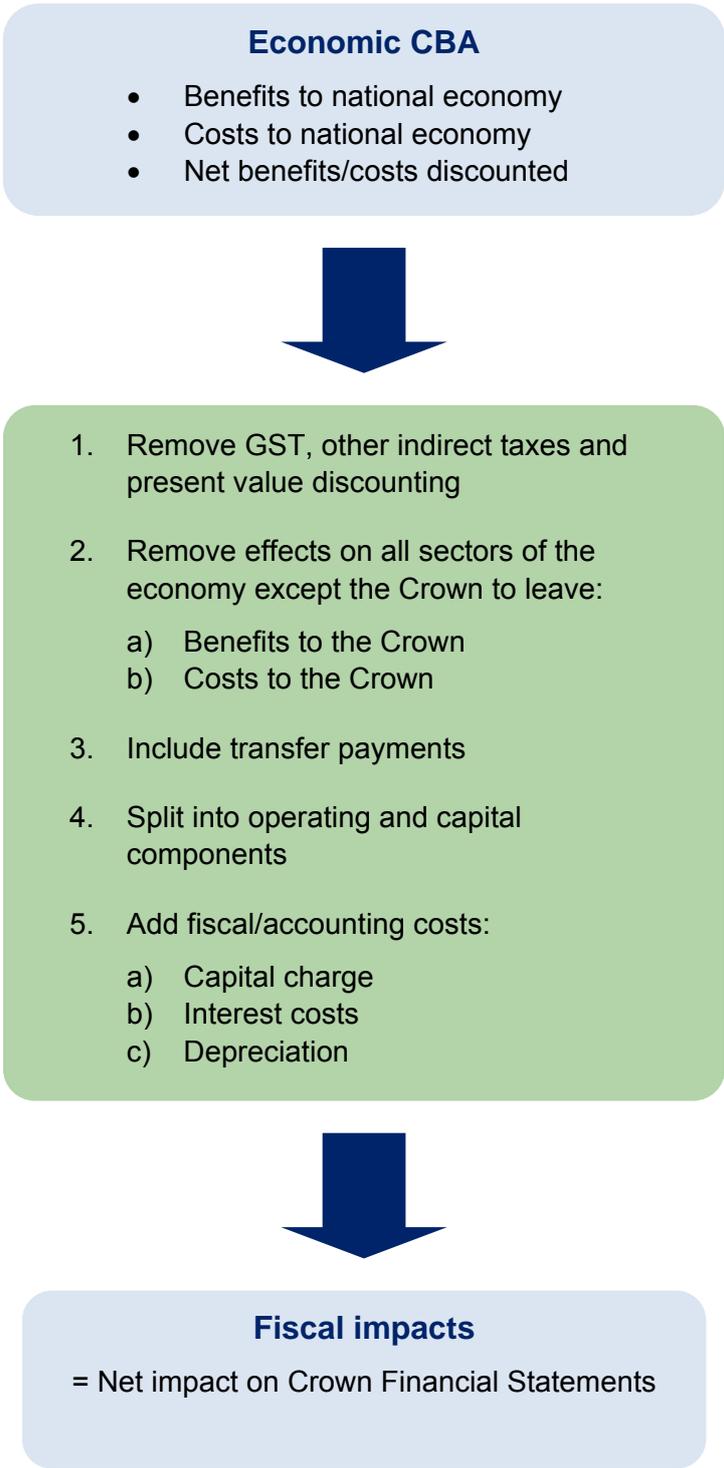
	Impacts across all economic sectors	Impacts across selected sectors	Economic costs and benefits	Accounting costs and benefits	Depreciation	Capital charge	Interest and financing costs	Taxes included in prices	Transfer payments included
National economic CBA	Yes	No	Yes	No	No	No	No	No	No
Financial analysis	No	Yes	Yes	No	No	No	No	No	Yes
Fiscal costing	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes

20. In addition, in contrast to financial analysis and fiscal costing, economic CBA is usually carried out in real terms, that is to say ignoring inflation. A higher discount rate would need to be used if the CBA was carried out in nominal terms.

21. Fiscal impacts/costings and economic CBA differ in four key respects:

- economic CBA includes effects on all sectors of the economy, while fiscal costings focus upon the government sector only,
- economic CBA uses discounting and often looks beyond the five-year horizon that is reported in the Crown financial statements,
- economic CBA reflects real resource use, while fiscal costings can include resource transfers and accounting items such as depreciation and capital charge, and
- economic CBA does not distinguish between capital and operating costs.

22. The relationship between economic CBA and fiscal impacts can also be illustrated as follows:



Step 3: Identify the costs and benefits

- All benefits and costs that impact on people should be taken account of in the CBA.
- Benefits and costs should be defined in terms of observable consequences on people.

23. Costs and benefits need to be identified as comprehensively as possible, and:

- Characterised in terms of impacts on people, rather than on organisations or decision-makers. For example, in a proposal to increase the capability of an organisation, increasing the capability of the organisation may or may not help its clients. It would be better to identify directly the impacts on the clients, such as “faster response times which save clients x hours of time, worth \$y”, or “reduced weather forecasting errors, which save farmers \$x in unnecessary irrigation costs and \$y in damaged crops due to failure to irrigate when they should have”, or “faster response times reducing processing costs and therefore requirement for taxpayer support through an appropriation”.
- Characterised in terms of observable consequences, i.e. in terms that are measureable.
- Checked to ensure that there is no double counting (see below).

24. As a general principle, only real costs and benefits, that is to say changes in real resources, should be taken into account:

- Payments to suppliers, while technically financial transfers, are proxies for the consumption of real resources.
- Accounting depreciation expenses should not be taken into account, since this would double-count the capital investment that has already been taken into account as a cost.
- Interest and departmental capital charge are payments for the time value of money and should be ignored as the time value of money is represented by the discount rate. A large portion of rent or lease payments also compensate for the time value of money, so care needs to be taken when incorporating rental charges into a CBA.
- As previously indicated, welfare payments transfer resources from taxpayers via the government to welfare recipients but do not represent either an increase or decrease in real resources.

25. Capital gains should generally be ignored as they either reflect a change in the market's discount rate or they represent the NPV of future increased earnings, which will be recognised in the cost benefit analysis. For example, the increase in property values that might result from, say, a new railway line, represents the capitalised value of the travel time savings that the railway brings about. To count both the capital gain and the increased travel time savings would double-count this benefit.

26. Only those costs and benefits directly attributable to the policy should be taken into account. If they would occur anyway, then they should be ignored.

21. Avoided costs or benefits also need to be included, provided they are a consequence of the decision that is to be made. Costs or benefits that do not change as a result of the decision should be ignored; for example, costs related to the policy that have already been incurred. However, opportunity costs should be taken into account; for example, the value of existing land holdings that will be used for a project but could be sold if the project does not proceed.

27. It is sometimes thought that costs and benefits to people breaking the law should be left out of the CBA. Since laws themselves should be subject to a CBA, it is consistent with an evidence-based approach to take all costs and benefits into account. If this is not done, a CBA will not be able to distinguish properly between the social outcomes of laws with harsh penalties and those with more moderate penalties.

Negative costs and 'dis-benefits'

28. Some analysts treat certain costs as 'dis-benefits' and net them off the benefits. The converse also occurs. This distorts the benefit cost ratio. Costs should be strictly in the denominator and benefits in the numerator.

29. Consider a road seal extension project, involving a capital expenditure in year 1, and maintenance cost savings in subsequent years. People sometimes put the capital expenditure in year one in the denominator and cost savings (ie, negative costs) also in the denominator. The numerator might include user benefits. As a result, the BCR can swing wildly. It might be zero if there are no user benefits and the only benefits are the cost savings. Or it might be infinite if the denominator is zero as a result of the cost savings being deducted from the capital expenditure.

30. The solution is that the maintenance cost savings should not be put in the denominator as a negative cost, but should be put in the numerator as a benefit.

Avoidance of double counting

31. Obviously, every cost and every benefit should be measured once and only once. The problem of double-counting occurs mainly because of vague descriptions. Suppose somebody tried to evaluate a transport project in terms of the following benefits:

- Improves general traffic journey times
- Impacts positively on wider network performance
- Impacts positively on movement of freight
- Facilitates economic growth
- Is economically efficient
- Is able to deal with peak period commuting passengers

32. All of these benefits arise because of increased capacity and faster journey times. More specific definitions of benefits such as:

- a) 'travel time savings multiplied by the number of vehicles',
- b) 'vehicle operating cost savings' and
- c) 'induced traffic'

avoid double counting and are also easier to measure.

33. There is also a risk of double counting when considering depreciation charges, interest and cost of capital.

34. For example, a **depreciation** charge is intended to reflect to 'consumption' of capital, or the reduction in the value of the capital investment over a specified period, but would double count the cost of an investment if the construction cost was already included in the CBA. Accounting practice is to treat construction cost as capital expenditure and to recognise depreciation as an operating cost. The usual practice in CBA is not to distinguish between operating and capital. Capital expenditure is therefore recognised when it is incurred, and depreciation is ignored. While the opposite would also be valid, doing it this way simplifies the task of ensuring that the time value of money is properly taken account of.

35. Similarly, **interest**, and the '**capital charge**' payable by government entities, should be ignored because they are part of the cost of capital, and already taken into account in the discount rate.

Externalities

36. Externalities, also known as 'spill-overs', are forms of what economists call 'public goods'. These are goods that, once produced, can be consumed simultaneously by any number of people (i.e. without congestion) and from which people can't be excluded. An example is broadcast TV (or was, before it became possible to encrypt the signal). A negative example is the smoke pollution created by a factory's chimney stack. These are situations where a transaction between the affected parties does not take place because the costs of defining property rights (for example by encrypting the TV signal) and negotiating a transaction exceed the benefits of doing so. As a result, a greater amount of negative externalities and fewer positive externalities are produced than if the parties were able to negotiate a price.

37. Governments are sometimes able to put arrangements in place that make people face the right prices without creating high transaction costs. The 'right price' is equal to the cost of making the good or service available for consumption by one more person. A 'carbon' tax would be an example, though whether it could be set at the right level would depend on whether it was possible to determine the resource cost that carbon emissions give rise to (in terms of adverse climate consequences). The effect of the tax is for people to take the cost of the externality into account in their actions, ie to 'internalise' the externality.

38. Externalities are quantified when doing CBAs in order to ensure that they are internalised in the spending decision or regulatory decision.

Induced behaviour

39. A CBA needs to take into account the behavioural changes that the policy will induce. For example, a new bridge not only shortens the trip for the existing traffic, it will also induce many people to travel who were previously put off by the long distance. The CBA therefore needs to estimate the additional demand that is induced by the policy, net of any reduction in demand elsewhere.

Deadweight cost of taxation

- CBAs should include a deadweight cost of taxation, equal to 20% of project costs that are funded from general taxation.

40. Most of the costs of a project typically arise from the consumption of resources, such as labour, materials etc. But additional costs arise where the funds for the project come from taxation. Taxes encourage people to move away from things that are taxed and toward

things that are not taxed or more lightly taxed. Their consumption choices are distorted away from what they would prefer in the absence of taxes. The change in the mix of consumption has an adverse welfare effect which is additional to the loss of welfare resulting directly from the loss of money that is taken away in the form of tax. This welfare loss is referred to as the deadweight cost of taxation (or sometimes as a deadweight loss, or 'excess burden').

41. By way of examples, income tax on labour income tends to discourage working in favour of leisure or home-based activities, and income tax on capital income (ie from investments) tends to discourage investment and saving in favour of immediate consumption². Attempts have been made at estimating these effects, with estimates varying from 14%³ to more than 50%⁴ of the revenue collected.

42. This guide suggests a rate of 20% as a default deadweight loss value in the absence of an alternative evidence based value⁵. Thus public expenditures should be multiplied by a factor of 1.2 to incorporate the effects of deadweight loss.

43. Note that some 'taxes' (such as the fuel excise duty) are calculated to reflect the value of an externality or the resource cost of providing government goods or services and therefore function like market prices; in such cases the deadweight cost is zero.

Step 4: Value the costs and benefits

- Benefits should be measured in terms of 'willingness to pay', and costs should reflect opportunity costs.
- Values should be adjusted for risk.
- Values should be expressed in terms of ranges.
- The evaluation period should be 'whole of life'.
- Benefits and costs should be measured in real terms, i.e. net of inflation.
- Multiplier effects should be ignored, unless there is high unemployment.

44. The previous three steps only require thinking and familiarisation with the issue, and should be carried out for all CBAs. Valuation of costs and benefits, however, is usually more difficult. But this is not a reason not to make an attempt. Even a rough, back-of-the-envelope attempt will convey some useful information to decision-makers. In fact, just identifying the main costs and benefits, and summarising them in a table on one page, often reveals surprisingly useful information. In other words, a 'rough' CBA is better than no CBA.

45. More information on how to do a rough CBA is provided on page 45 and a worked example in appendix 2.

² This was particularly evident when New Zealand had a top marginal tax rate of 66%: This would have discouraged some workers from working over-time.

³ Diewert, W.E. & Lawrence, D.A. (1994) *The Marginal Costs of Taxation in New Zealand*, Wellington: New Zealand Business Roundtable.

⁴ Bates, W. (2001) How much government? The effects of High Government Spending on Economic Performance, Wellington: New Zealand Business Roundtable, p.viii; Feldstein, M. (2005) "Rethinking Social Insurance", *American Economic Review*, Vol. 95: No.1 (March 2005), p.9.

⁵ By way of comparison, both the Australian CBA guide and the US "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs" suggest that the marginal deadweight loss of general taxation is around 25%.

Measure of Value: Willingness to pay

46. People's willingness to pay for a service (or 'willingness to accept' payment as compensation for suffering a disadvantage, eg exposure to pollution) reflects their ordering of preferences; that is to say, if they are prepared to pay more for one service than for another, then it seems reasonable to infer that the first service impacts more positively on people's welfare (or at least on their perception of their own welfare). Using willingness to pay (or accept payment) measured in dollars, therefore ensures that all costs and benefits of all project alternatives are compared using a common yardstick.

47. While it is recognised that willingness to pay depends on ability to pay, any ethical or equity issues that arise should be noted in the CBA report and on the summary CBA table, but should be discussed separately. It is generally not practical to attempt to quantify them and include them in the numerical evaluation.

Opportunity cost

48. 'Willingness to pay' is a measure of the value of a project's outputs. The costs of inputs to a project should be measured in terms of their 'opportunity cost', which is the value of the opportunity that is forgone. For example,

...take the case of time savings for non-business travel. For the travellers, such savings are equivalent to some increase in their income. Say that people are indifferent between receiving a windfall of \$10 and saving an hour off their trip to the beach. A CBA of a highway to the beach would then value an hour saved at \$10⁶.

49. Economic theory shows that in undistorted competitive markets, market prices of goods and services are equal to their opportunity costs. Where there are no competitive markets, various techniques can be adopted to estimate the opportunity cost of a cost or benefit. These are discussed further below.

Employment effects: the opportunity cost of labour

- A CBA should generally assume that the opportunity cost of labour is the going wage rate.
- However, to the extent there is unemployment in the relevant skill classes in the project's catchment area, the opportunity cost of labour can be assumed to be half the going wage rate for the skills that the project employs.

50. If there is no unemployment, then the opportunity cost of labour is equal to the pre-tax wage.

51. If there is unemployment, then some analysts will assume that the opportunity cost of labour is zero. However, that would imply that some people would be willing to work even for \$0.01 per hour. This is clearly not right for most labour.

52. Much unemployment is caused by labour market 'frictions'. That is to say, people prefer to be unemployed and search for a better job, than take the first job available. Their opportunity cost is at least as high as the wage of the job they could have had but rejected in favour of searching for a better job.

⁶ Luskin & Dobes (1999), p.3.

53. There may be people whose personal productivity is low and who therefore have a low opportunity cost. That means they are effectively unemployable if there is a regulated minimum wage. They can't be reached by a project that is required to pay at least the minimum wage. The minimum wage is therefore the minimum labour opportunity cost for projects. The opportunity cost of labour will be higher where a project demands labour that commands a higher wage than the minimum wage.

54. There are also people who have skills but not those for which there is demand. They are effectively unemployable, but they might become employable if a new project comes along that requires their skills. These people have an opportunity cost equal to the value of the leisure that they would have to forego.

55. The value of their leisure will range from zero in the case of some people, to just slightly less than the going wage for their skill in the case of others. Most people will fall somewhere in between. As a first approximation, half the going wage for the skill in question is likely to be a reasonable estimate of the average opportunity cost for these people.

56. In the context of a CBA, a reasonable approach is therefore to consider how many people in the project's labour catchment area are involuntarily unemployed and have skills that the project requires (ie, whose personal productivity in this skill exceeds the minimum wage but in other skills is less than the minimum wage). For these people, the opportunity cost of labour is half the going wage. For any other labour that the project requires, the opportunity cost is the going wage.

Valuation techniques

57. Estimates of many costs and benefits may be based on market prices. However, in some cases market distortions, including externalities (such as pollution), mean that market prices are inappropriate. In other cases there are no markets for the goods in question. Externalities and non-market goods (sometimes referred to as extra-market goods) can be valued by revealed preference methods, stated preference methods, and combinations of revealed and stated preference methods.

Market prices

58. Where goods or services are regularly traded in a market and there are no significant market distortions, including externalities (such as pollution), the prices of current market transactions can be used as a reasonable guide to future prices, adjusted for any changes that might be reasonably expected over the forecast period.

Price forecasts

59. In general, it is best to assume that prices will remain constant in real terms. Just because the price of something has risen continuously for the last 10 years, it doesn't follow that it will keep rising. In fact, in many situations the likelihood of a market correction increases as time passes.

60. If there is a futures market for a commodity, then the price in the futures market should be used, as this reflects the market consensus. While it is sometimes tempting to conclude that the market is providing incorrect signals because it is driven by speculators rather than fundamentals, this itself would be a speculative view that may be inappropriate when managing public funds.

Primary and secondary markets

61. The primary market for the outputs of a project is the people or firms who are directly affected by the project. However, these are often not the final beneficiaries (i.e. consumers) of the good or service. For example, a travelling salesman who uses a faster road will be able to provide a more effective or cheaper service to another firm, which in turn may provide services to a company that manufactures goods for consumption by households. If the salesman and the other firms operate in competitive markets, they will not be able to increase their profits and will therefore not be able to retain any of the benefit for themselves. In other words, the benefits of the project are passed on through the production chain down to the final consumers. It is those consumers who are the true beneficiaries of the road. The markets for goods and services to which the benefits of the primary market have been passed on are collectively referred to as the secondary markets.

62. Is the 'willingness to pay' of the people or firms in the primary market a sufficient measure of the benefits of the project?

63. This depends on whether the secondary markets are competitive and free of market distortions (externalities or public goods). If market participants attempted to retain some benefits in order to increase their profits, competitors would enter the market and compete their customers away with lower prices or better services. If markets are competitive and undistorted (fairly true for most of the New Zealand economy), one can therefore assume that competition will force all market participants to fully pass on the project benefits to their customers and to the final consumer.

64. In practice, secondary markets are not fully competitive and undistorted. However, the impacts of the distortions on the benefits as measured in the primary market are generally very difficult to measure. Attempts to do so are being made in the case of the agglomeration and other effects of transport projects, around which there is a growing literature. See, for example, NZTA (2011). Fortunately, the effects in secondary markets are likely to be relatively small, given the overall margin of error in a CBA, and can therefore safely be ignored. For a more comprehensive discussion, see chapters 4 and 5 of Boardman et al (2010).

Multiplier effects

65. Proponents of projects often claim that their projects have multiplier effects. They claim that the expenditure on the project provides income for construction workers and for operating and maintenance staff, who will spend their wages and create income for local businesses, which in turn will spend their income and create income for other businesses, etc. This thinking either assumes that there are significant unemployed resources available, or it ignores the fact that the new activity displaces other activity that would have occurred. Unless there is significant unemployment of people with the requisite skills, it is therefore likely that multiplier effects do not exist. See also page 54 (General Equilibrium Analysis).

When market prices are not available

- There are a number of methods for valuing the outputs of government projects when market prices are not available.
- Statistical methods can be used to infer people's willingness to pay from observations of prices in related markets (revealed preference methods).
- Where related markets don't exist, such as in relation to "non-use" values, certain kinds of stated preference methods can produce reasonable valuations, if properly validated.
- Non-market valuation is a specialised field and requires expert advice.

66. Market prices for the outputs of government projects are typically not available. The amount that people would be willing to pay for these items, or their willingness to accept compensation for changes that disadvantage them, is the appropriate measure of value of non-market items for cost-benefit analysis. Demand for non-market goods can be estimated with two broad classes of methods; related market and hypothetical market methods, sometimes referred to as revealed and stated preference methods.

67. The most common categorisation of types of value is the Total Economic Value framework, which divides values into two broad categories; use values and non-use values. Use values can be extractive or *in situ*, and may also be differentiated depending on whether they are associated with markets. For example, supply of irrigation water from a river is an extractive use that has associated market values. The benefits of irrigation, and hence the use value of the water extracted, can be estimated from market information. Irrigation water abstraction may affect kayaking, a non-extractive use, which may have commercial aspects (market value). However, non-commercial recreational kayaking is a non-marketed use value that requires non-market valuation. Non-market use values can be estimated with stated preference methods and sometimes with revealed preference methods.

68. Irrigation water abstraction may also degrade habitat for endangered fish and bird species, reducing or eliminating local populations. People value the fish and birds and the well-functioning ecosystem, even if they do not personally visit the river. These "existence values" are non-use values, which require non-market valuation. By definition, there are no associated markets for non-use values so they can be estimated only with stated preference methods.

Related market (revealed preference) methods

69. Sometimes purchases in related markets can be used to provide information on non-market values. Revealed preference methods use information from such markets to estimate either demand functions or the monetary value of changes.

Mitigation expenditures (or defensive expenditures)

70. In some cases it may be possible to use observations of defensive expenditures to infer values. In situations where there are no other benefits from the mitigation action, mitigation expenses can provide a lower-bound estimate of the cost of the effect. This approach requires great care because defensive actions may not eliminate the effect being valued, or may provide other services.

71. Installation of double-glazing for noise impact mitigation is a good example. For some people the cost of double-glazing is more than the value of the noise effect, so these people continue to suffer the cost of the noise without registering any “value” through the defensive expenditure market. Further, installation of double glazing does not eliminate outdoor noise, and may not eliminate indoor noise effects, so mitigation is incomplete. Together, these failures to achieve full mitigation suggest that mitigation expenses are under-estimates of the value of noise impacts. However, double-glazing provides other benefits, including reduced energy bills, a more comfortable indoor environment, and reduction of noises other than those that are being valued (for example, suppose airport noise is the focus of the study, but noise from road traffic, trains and neighbours would also be reduced by double-glazing). Hence, the decision to incur the expense of double glazing may be based largely on factors unrelated to the cost being valued, in which case the expenditure may be an over-estimate of the value of noise impacts. Because there are potential biases in both directions, the overall direction and magnitude of bias is often unknown. Careful statistical analysis may permit identification of the significance of the effect of interest.

Market prices of close substitutes (replacement costs)

72. Where the cost of a proposal involves the loss of something of value rather than a cash outlay, the cost of replacing that thing is only a valid measure of mitigation when benefits from replacement exceed its cost, or where mitigation is a legal requirement. For example, consider a community recreation area that would be lost if a proposed development proceeds. The community values the area at \$500,000. If replacement costs \$200,000 then that is the correct value to use in CBA to assess the value of the loss. However, if replacement cost was \$700,000 then it would not make sense to undertake replacement and the loss of \$500,000 would be the relevant measure to use in CBA. In either case, the appropriate measure is the amount of compensation required to restore the community to their original level of welfare. Hence, replacement costs for lost or damaged facilities do not always provide valid estimates of the value of what has been lost. Put simply, what has been lost may have little value, but could be very expensive to replace. The relative magnitudes of benefits and costs can only be ascertained through independent valuation of costs and benefits, and should not be assumed - in the hypothetical example above it is not known whether it is appropriate to use the replacement cost without knowing that the true value is \$500,000, which requires some alternative form of valuation.

Hedonic analysis

73. The Australian CBA guide describes hedonic analysis as follows:

“Hedonic analysis shows the implicit prices of the attributes of goods (or assets). Hedonic analysis can be applied to any product with multiple attributes and to any occupation with multiple workplace attributes. The basic idea is that the value of something is the sum of the value of its attributes.”

A common application of the hedonic price method is the valuation of environmental amenity by analysis of house prices associated with the environmental attributes of the houses. This is usually done by a multiple regression study of house prices and their determinants, including environmental attributes.”

74. For example, hedonic analysis can be used to compare the differences in prices of houses as a function of their distance from a park, after accounting for differences in other property and neighbourhood attributes, providing information on how home owners value parks.

75. Other applications include the estimation of the value of safety in the workplace from differences in wage rates, and, therefore, by extrapolating from the value attached to small changes in risk, the value of a statistical life.

76. Hedonic analysis relies upon observed behaviours to infer value. However, behaviours are reliant on the perceptions of market participants and the constraints they face. Hedonic analysis assumes well-functioning markets, and entails analyst choice about functional form and statistical modelling, which can have dramatic implications for estimated values.

77. It is common (at least overseas) to use hedonic housing market information to assess the value of pollution, noise, and other environmental amenities. However, many market participants may be unaware of the levels of the environmental attributes (e.g. presence of water pollutants), or the nature of the effects (types and prevalence of health effects caused by the pollutants). If that information is not reflected in the choices of market participants then hedonic analysis is inappropriate. Information disparities may also affect market outcomes. For example, property vendors may be aware of the environmental effects, which may be motivating the sale, but have an interest in not revealing such information to unknowing buyers. Imperfect perceptions do not affect readily observable attributes, such as proximity to native forests or public transport services, but might be important for unobservable or intermittent effects, such as risks from hazardous wastes.

78. There are large transaction costs associated with both housing and labour markets. Hence, there is market stickiness, and jobs and houses may not be optimally allocated. Markets can be highly dynamic, and effects like rapidly escalating property value bubbles may preclude obtaining information on sufficient trades within the same market. Similar effects occur in hedonic wage models. Working hours and wages may be the result of “awards”, be fixed, or be dependent upon the power of union negotiators and employers in a bilateral monopoly. High unemployment may prevent free movement between jobs. Wage rates are unlikely to represent marginal values in such cases.

Statistical issues

79. Hedonic models estimate demand in a two stage process. In the first stage property sale prices are modelled as a function of property and neighbourhood attributes (e.g. number of bedrooms, school zones, etc., and the attribute that is being valued). This process identifies the supply function, which reveals implicit prices (supply costs) for attributes. These implicit prices are not estimates of willingness to pay, which is derived in the second stage, requiring market segmentation or information from several different markets. Interpretation of implicit prices as marginal values requires untenable assumptions.

80. There are many correlations in property markets. For example, modern, large, high quality houses are not usually built next to hazardous waste facilities, transport depots, or polluted waterways. However, those same properties may be associated with superior schools, health care facilities, prestigious suburbs, and so on. These correlations may prevent reliable estimation of statistical models, or confound numerous effects thereby preventing isolation of the value of interest.

81. For all the reasons discussed above, there are limited applications where hedonic analysis can provide reliable information about non-market values.

Travel cost analysis

82. Recreational and other travel-related (e.g. commuter mode choice) amenity values can be estimated by using time and money costs as related-market proxies for costs, and assessing how changes in these costs affect chosen alternatives and/or frequency of use.

83. Information requirements are relatively low. Residential location, and recreational site choice, either on a specific location or over a specified time period, are the fundamental needs. The analyst can then independently identify each individual's cost of visiting the study site and substitute sites, and the qualities of attributes at each of those sites. Observed site choice and/or frequency is then modelled as a function of visit costs and attribute levels for all sites. Behaviour is usually modelled using sophisticated random utility models employing individual level data. Site choice models allow identification of the demand curve for specific sites or changes in site attributes by mapping the change in site use as a function of changes in costs.

84. Whilst travel cost models are sometimes claimed to be unbiased because they rely upon observed behaviours, they entail significant analyst choices that can have dramatic implications for estimated values. Important aspects include decisions about the functional form of the demand curve, which costs are measured, how costs are measured, treatment of multiple-purpose trips, and so forth. Hence, sensitivity analysis to identify the potential range of values is paramount.

Benefit transfer

85. Benefit transfer, also known as value transfer, is simply using results of previous studies of analogous situations (source values) to provide information about values of the case under consideration (study values). Benefit transfer can be inexpensive and rapid if suitable source studies are available. Source values can be transferred to the study project as point estimates, value functions, or as meta-analyses.

86. Meta-analyses, which draw information from a large number of previous studies, provide useful information on source study valuation contexts, and identify adjustments required to transfer source estimates to the study case. Meta-analysis also provides an indication of the variability of value estimates and so is recommended rather than point and value function transfers from individual sources or a small number of studies.

87. Great care is required to match source and study scenarios. Non-market values are highly sensitive to context and can vary because of differences in the nature of the resource, the availability and prices of substitutes and complements, underlying preferences, cultural context, environmental value orientations, socio-economic characteristics, demographics, population density, transport availability, and other matters.

88. Even the most careful and comprehensive benefit transfer studies can be extremely inaccurate. Hence, benefit transfer is recommended primarily as a useful aid in determining whether non-market values are likely to be significant for the project under evaluation, and whether a primary valuation study is warranted.

89. The international Environmental Valuation Reference Inventory (EVRI, www.evri.ca) provides source study information for benefit transfer from many thousands of non-market studies undertaken worldwide, including studies from New Zealand. However, international benefit transfer adds additional complications because of currency and cultural differences. New Zealand studies can be identified at www2.lincoln.ac.nz/nonmarketvaluation/

Hypothetical market (stated preference) methods

90. Stated preference methods are versatile, and can measure use and non-use values, whereas revealed preference methods are incapable of estimating non-use values. Non-use values are values that people assign to economic goods (including public goods) even if they never have and never will use them. They are distinguished from use values, which derive from direct use of goods. Examples of non-use values include the values of endangered species preservation, environmental degradation, landscape change, and many health-related matters, amongst others. The only methods available for measuring non-use values are hypothetical market, or stated preference, approaches. The most common stated preference methods are contingent valuation and attribute-based methods.

Contingent valuation

91. Contingent valuation has evolved significantly since it was first employed in the early 1960s, when participants were simply asked what a non-market item was worth to them. There are many variants, each with associated biases. Some biases arise from the hypothetical foundation of contingent valuation, while others arise from psychological processes, and information or incentive cues to respond in particular ways. The debate about the validity of contingent valuation and methods appropriate for its application has spawned an extensive academic literature which continues to grow. However, a range of different reliability tests have shown that contingent valuation that employs recognised best-practice approaches yields reliable (but not precise) information on non-market values. Consequently, contingent valuation is supported and applied by many national governments and international agencies. For example, the New Zealand Government's value of a statistical life was derived using contingent valuation.

92. The essence of contingent valuation is comparison of two states of the world (with/without the project). Outcomes are described for both cases, typically including one attribute measured in monetary units. Participants evaluate the difference in value to them of the two sets of outcomes, providing information to the analyst on one of a variety of scales. Single-question dichotomous choice contingent valuation is the only form that is theoretically incentive compatible. It does not ask for statements of value per se, but asks participants to nominate their preferred alternative and statistically analyses responses from a large number of participants to identify the value of the non-monetised aspects as a package.

93. Approaches other than single-question dichotomous choice are inherently biased and either should not be used, or their biases should be recognised if that is useful in the decision-making context. For example, an approach that over-estimates values may be helpful if it shows that the particular values are not significant in the decision being made.

94. Contingent valuation analysis relies upon participants making choices in a manner consistent with analyst expectations. However, some people adopt simplified decision heuristics, misunderstand the process, or behave strategically, so their choices are inconsistent with the analyst's conception. Hence, it is extremely important to validate the understanding and behavioural processes of contingent valuation participants. It is also important to validate that overall results are consistent with underlying expectations, such as income effects, sensitivity to scope, and so forth. The academic literature provides guidance on appropriate validation methods.

Attribute-based methods

95. Contingent valuation measures the value of a single, prescribed package of inseparable changes (e.g. a wetland enhancement project's outcomes could be specified as the following package: 20% increase in bird breeding frequency, 10% increase in kokopu population, decrease in peak stream flow of 5 cumecs). Contingent valuation does not reveal the values of changes in the individual components. For example, contingent valuation cannot distinguish the magnitude or relative importance of the kokopu population change and the change in bird breeding frequency. Attribute-based methods value changes in each of the attributes, such as the kokopu population, that constitute the package. Approaches include choice experiments, contingent ranking, best/worst and paired comparison studies, amongst others. The most common method is the choice experiment, sometimes referred to as choice modelling. Choice experiments ask respondents to nominate their single preferred alternative from several options specified by different sets of attribute levels.

96. Choice experiments have a number of advantages over contingent valuation. There are psychological advantages to the way the questions are posed, particularly because participants are not forced to choose between only two outcomes, neither of which may be desirable to them. Choice experiments de-emphasise the monetary trade-off, reducing opportunities for strategic responses. Most importantly, choice experiment results do not value a single, pre-specified outcome. Hence, they are useful when expectations about outcomes change, after project design changes, and for aiding project design. New Zealand applications have been associated largely with designing and evaluating road transport policy and identifying the relative importance and monetary values of environmental attributes.

97. Successful modelling of preferences with attribute-based methods is contingent upon appropriate statistical design of the choice alternatives put before participants. Design and analysis both require advanced statistical modelling skills, requiring expert guidance.

Combined revealed preference/stated preference methods

98. Revealed preference approaches cannot be used to make predictions outside observed ranges, which limits their applicability in many policy evaluations. On the other hand, stated preference approaches are able to measure values outside observed ranges, but can be subject to biases because they are hypothetical. Combining revealed and stated preference approaches can, in some cases, mitigate these issues by using revealed preferences to calibrate stated preferences and using stated preferences to go beyond observed ranges. This combined approach requires a high level of statistical sophistication, so should be undertaken only by experts.

Concluding note on non-market values

99. Non-market valuation is a highly specialised field. Obtaining expert advice on the likely significance of non-market values and availability of appropriate valuation methods is recommended. Likewise, estimation of values by experts is recommended.

Thought experiments

100. Even where the analyst has to guess the value of a benefit, there are techniques for making the guess intelligent and informative. The use of confidence intervals, rather than point estimates, will reveal to the decision-maker the extent of the guessing.

101. Calibrated guesses provide more useful information to the decision-maker than leaving the benefit ‘unquantified’, or resorting to multi-criteria analysis. A decision-maker will generally find it easier to agree or disagree with the opinion of an analyst, provided it is given honestly (ie, with confidence intervals), than to have to make up his or her own mind in a vacuum of information.

102. This section explains how to deal with particularly difficult costs and benefits, and illustrates how an intelligent guess can be made about the value of a benefit and how it can be improved through ‘calibration’. However, the techniques for improving the confidence intervals can, and should, be applied equally to costs and benefits that are easier to quantify.

103. Consider a situation where it seems clear that a benefit exists, but at first blush there seems no practical way of quantifying it. An example might be the contribution that an extra \$100 million in the Defence budget might make to New Zealand’s strategic interests.

104. **Firstly**, clarify the objective in terms of observables. Start by decomposing an uncertain variable into several parts to identify which observables you can most easily measure. Eg, ‘improves ability to reduce trade barriers’. Or, ‘improves ability of our security services to cooperate with other services and reduce risk of terrorism’. Clearly, the objective can be broken down into a number of specific benefits. Each one will need to be considered individually. It is often the case that decomposition itself – even without making any new measurements – reduces uncertainty about the variable of interest.

105. **Secondly**, determine a confidence interval for each of the benefits. Using the example of a reduction in the risk of terrorism, it is necessary to estimate:

- the probability of a terrorism event given the level of cooperation between security services that would exist if the Defence budget were not increased,
- the reduction in probability of a terrorism event happening as a result of the increased cooperation between security services,
- the average cost of an event.

106. The benefit is equal to the reduction in terrorism events multiplied by the average cost of an event. A best estimate of the first of these three elements can be obtained by undertaking the following steps:

Step 1: In the absence of better information, guess the probability of a terrorist event in New Zealand in any one year. We might guess that, in the absence of an increase in the Defence budget, the probability is, say, 7% (one event in 15 years), with a 90% confidence interval (CI) of plus 3% or minus 2% (plus or minus 5 years).

Step 2: Calibrate the confidence interval using one of the following techniques⁷:

Equivalent bet test: Suppose you can win \$1,000 in one of two ways:

- You win \$1,000 if the true probability falls within your 90% CI. Otherwise, you win nothing.

⁷ Adapted from “How to Measure Anything” by Douglas Hubbard

- You spin a dial divided into two “pie slices,” one covering 10% of the dial, and the other covering 90%. If the dial lands on the small slice, you win nothing. If it lands on the big slice, you win \$1,000.

If you find yourself preferring option 2, then you must think spinning the dial has a higher chance of winning you \$1,000 than option 1. That suggests your stated 90% CI isn't really your 90% CI. Maybe it's your 65% CI or your 80% CI instead. By preferring option 2, your brain is trying to tell you that your originally-stated 90% CI is overconfident.

If instead you find yourself preferring option 1, then you must think there is *more* than a 90% chance your stated 90% CI contains the true value. By preferring option 1, your brain is trying to tell you that your original 90% CI is under confident.

To make a better estimate, adjust your 90% CI until option 1 and option 2 seem equally good to you. Research suggests that even *pretending* to bet money in this way will improve your calibration.

Repetition and feedback: Make lots of estimates and then see how well you did. For this, play CFAR's Calibration Game⁸.

Identify reasons why a particular estimate might be right, and why it might be wrong.

Look more closely at each bound (upper and lower) on their estimated range. A 90% CI “means there is a 5% chance the true value could be greater than the upper bound, and a 5% chance it could be less than the lower bound. This means the estimators must be 95% sure that the true value is less than the upper bound. If they are not that certain, they should increase the upper bound... A similar test is applied to the lower bound.”

Step 3: repeat the calibration of best guesses and their CI for the other components of the ‘reduction in terrorism’ benefit, and for all other benefits.

Step 4: undertake a Monte Carlo simulation in order to arrive at a net present value estimate and its 90% confidence interval (see appendix 1).

Taxes and subsidies

- All prices used in CBA should be tax- or subsidy-exclusive.

107. Tax and subsidy exclusive prices should be used in economic CBA. This means that costs involving government expenditure should be exclusive of GST⁹ and any other indirect taxes.

108. It is also appropriate to adjust market prices for the effect of taxation where this may make a material difference to the decision on the preferred proposal. In practice, it is relatively rare that adjustments for taxation are required, because similar tax regimes usually

⁸ <http://acritch.com/credence-game/>

⁹ Economic analysis on a GST-inclusive basis would in principle be equally valid provided GST-inclusive figures are used consistently. Note that Government expenditure is appropriated on a GST-exclusive basis. Presentations to Ministers (e.g. Cabinet papers) should therefore also be GST-exclusive.

apply across the range of alternative proposals. However, where tax regimes applying to different alternatives vary substantially, adjustment is necessary to avoid distorting the option choice.¹⁰ This avoids a situation where tax considerations (which are transfer payments not a net benefit to society) drive investment choice.

109. Care needs to be taken with the indirect tax on petrol. This is really a kind of user charge and therefore akin to a price for using roads. If, for example, the desired outcome was to reduce the time taken to commute to work in a given city, and were comparing roading proposals to other options such as rail and ferries, the indirect tax on petrol should not be removed to ensure consistency across proposals.

Sunk costs

110. Sunk costs are costs incurred before the start of the appraisal period and for which there is no value to the resources in some alternative use. Common examples include the costs of policy development or feasibility studies undertaken at an earlier date. Sunk costs are not included in an economic CBA because there is no opportunity cost involved and their inclusion may distort the analysis at hand by requiring a very high return on the investment. Put another way, sunk costs are irrelevant because they are the outcome of past decisions and should therefore be excluded from future decisions.

111. This treatment of costs is often at odds with the accounting approach to costs.

112. Where the asset or investment does have an alternative use, and therefore a market value, eg, land that was acquired some time previously, then it should be included in the CBA.

Real option values

- Where new information is expected as a result of the passage of time, the option of delaying a project by different amounts of time should be evaluated as separate alternative projects.
- Real option values should be included in a CBA if the partial completion of a project is expected to reveal new information that is relevant to the CBA.
- In that case, expected values should be calculated based on a properly formulated decision problem.

113. The terminology in the literature around option values is confusing. 'Option value' often refers to 'non-use values'. A financial option refers to an option to buy or sell a financial security. 'Real option' is essentially the same, but is used in the context of real projects, and could involve buying, selling, expanding, delaying or abandoning the project or a part of it.

114. Although the concept of real option values goes back at least to Arrow and Fisher (1974), their inclusion in CBA began to be more seriously considered after Dixit and Pindyck (1994) and represents an important analytical advance on orthodox CBA that takes as given assumed future streams of costs and revenues or benefits.

¹⁰ UK Greenbook, Chapter 5, <http://greenbook.treasury.gov.uk/chapter05.htm#fortaxes>.

115. An important implication of considering real option values is that consideration should be given to alternative ways of carrying out or delaying a project, some of which include the ability to build in or exploit flexibility. If it gives rise to an option value as a result of such flexibility, a slightly more expensive way of carrying out a project may be preferable to the cheapest way of carrying out the project if it has no such flexibility.

116. Two kinds of real options can be distinguished: where new information is expected to arise

- after the passage of time (exogenous learning, which increases the value of delaying the project), or
- after the project is begun (endogenous learning, which increases the value of starting the project early).

117. The value of the option is the difference between the expected value of the CBA with the option (ie, a two-period decision problem) and the one-period decision CBA that incorrectly ignores the opportunity for learning.

New information due to passage of time

118. In the first of the above two kinds, the option of delaying a project can simply be evaluated as a separate alternative project.

New information as a result of undertaking the project

119. For the second kind of option, rather than include the option as a separate benefit category, the better approach is to calculate expected values directly based on a properly formulated decision problem.

120. Options create a multiple-period decision problem: the first decision is whether to commence a project, and the second or subsequent decisions are whether to amend or abandon the project following receipt of new information. An example of a two-period problem is a financial put option, which gives the holder the right to decide at some point in time whether to sell a financial instrument at a pre-agreed price. An example of a real option might be the drilling of an oil well: a geological analysis of core samples obtained after drilling down to the half-way point might yield useful information about the likelihood of oil being found. At that point, there is an opportunity to make a further decision as to whether to continue with the drilling or whether to abandon the well.

121. There are broadly three techniques that can be used to analyse such options: decision trees, Monte Carlo simulations and the Black-Scholes model. Of these, the decision tree approach is by far the most flexible and powerful if there are a small number of major uncertainties, and is conceptually simple to apply. The following example illustrates this approach.

122. Example:

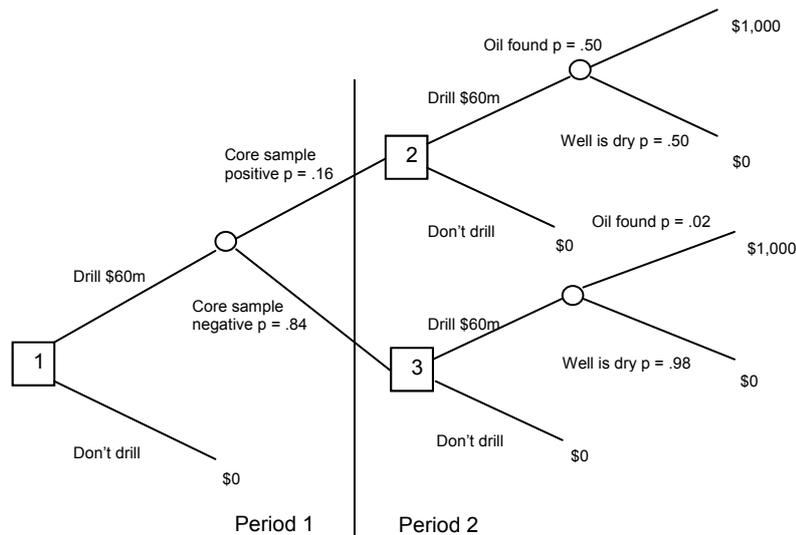
Consider a \$120 million project to drill an oil well that, from experience, has a 90% chance of turning out to be dry and a 10% chance of producing oil with a present value of \$1 billion. The net present value is \$1 billion times 10% less the cost of \$120 million, which is equal to an expected loss of \$20 million. The project would not seem worthwhile.

However, suppose that it is known that half-way through the drilling, new information will present itself that will provide an option to abandon the project. Suppose that it is

expected that when \$60 million of the cost has been incurred, there is a 16% chance that the analysis of the core samples will suggest that oil will be found, but that the core sample information is only 50% reliable. If the core sample is positive, then there is a 50% chance that it is right and oil is found. But if the core sample is negative, then there is a 98% chance that the well will be dry, with a residual chance of 2% that oil will be found. Under these expectations, should the drilling commence?

The decision problem is shown schematically in figure 1. Squares denote decisions and circles denote contingencies:

Figure 1



The expected net present value of this 2-period decision problem is worked out from right to left, as follows:

- The expected value of drilling in decision 2 is equal to the weighted average value of the two branches less the cost of the decision, plus the value of not drilling (\$0 in this case). The weighted average value is \$1,000m times the probability (0.50) plus \$0 times the probability (0.50), or \$500m. The cost of this decision is the drill cost of \$60m. The net expected value of this decision is therefore \$440. This is greater than the expected value of not drilling, which is \$0. Decision 2 should therefore be to drill.
- Similarly, the expected value of drilling in decision 3 is equal to \$1,000m times the probability (0.02) less the drill cost of \$60m, or -\$40m. This is worse than the expected value of not drilling (\$0), so decision 3 should be not to drill.
- The expected value of decision 1 is the expected value of drilling plus the expected value of not drilling. The expected value of drilling is the expected value of decision 2 (\$440) times the probability (0.16) plus the expected value of decision 3 times its probability (0) less the cost of that decision (\$60), ie, \$10.4m. This is greater than the value of not drilling, which is \$0.

The expected value of the project described in figure 1 is \$10.4m, which is greater than the expected value that was calculated if the new information from the core samples is ignored.

Uncertainty: Use of Ranges

123. CBA is essentially a forecasting exercise. It forecasts the benefits and costs to which a project will give rise. As such, the exercise faces the same problems that bedevil all kinds of forecasting of complex systems that are not well understood. This does not, however, invalidate the exercise. On the contrary, the complexity of the system, and the cost (and benefit) magnitudes usually involved, mean that a systematic, analytical and peer-reviewed approach is likely to produce a forecast that is more probable than alternative intuitive approaches.

124. Given that valuations are uncertain and approximate, it is more honest to provide ranges rather than point estimates. The ranges should ideally represent a 90% confidence interval¹¹. In other words, the analyst should be 90% confident that the true value lies within the range that has been specified. If no empirical evidence is available, thought experiments can be carried out (see page 25) to test whether it seems likely that the true value has less than a 5% probability of being below the identified range, and less than a 5% probability of being above the identified range.

125. A corollary of this is that almost all costs and benefits can be quantified, in the sense that it is almost always possible to assign confidence intervals that are less than infinite. Even a very wide range provides some useful information.

126. If costs and benefits are represented by ranges, then a Monte Carlo simulation (explained below) may be needed in order to determine the range for the net present value or the benefit cost ratio.

Optimism Bias

127. The UK Green book states on p.85 that “If no obvious empirical evidence is available, this may indicate that the project is unique or unusual, in which case optimism bias is likely to be high”.

128. Optimism bias occurs when favourable estimates of net benefits are presented as the most likely or mean estimates. It is an endemic problem in cost-benefit analysis and may reflect overestimation of future benefits or underestimation of costs.

129. The first remedy is to consider explicitly a pessimistic scenario for each of the benefits and costs, and for all of them in combination. It is also useful to consider whether there is benefit in waiting before proceeding with the project. A fuller approach is to determine confidence intervals for each benefit and cost, with separate attention given to each end of the confidence interval, and conduct a Monte Carlo simulation in order to determine the 90% confidence interval for the overall CBA.

130. In his book *Thinking, Fast and Slow*, Nobel prize winner Daniel Kahneman (Kahneman, 2012) suggests using a “pre-mortem” to rid (or reduce) a group of people of optimism bias. In a pre-mortem, the group imagines that they are having a conversation about why a project failed (or the benefits weren’t as high as suspected, or the costs were higher), before the project is undertaken. Members of the group come up with reasons why it might have failed. This helps people to calibrate themselves more accurately.

¹¹ This term is not being used in the formal sense of statistical theory, but loosely in the sense that the analyst is subjectively 90% confident that the ‘true’ estimate is somewhere within this range, given uncertainties about both data as well as assumptions. See Manski (2013), especially p.21-22.

Adjustment for Risk

131. Costs and benefits should be adjusted for risk. For example, if we think that a project produces a benefit of \$10 million in a given year, but that there is a 25% chance that there will be no benefit, then the risk-adjusted benefit is \$7.5 million.

Evaluation Period

132. Costs and benefits should be estimated for each period in the life of the project. 'Periods' are typically years. Sometimes it is convenient to evaluate the project over less than its whole life, eg, 10 years, but this might result in the underestimation of benefits. Whole of life evaluations are therefore preferable.

Nominal vs Real

133. It is usually more convenient and less confusing to value costs and benefits in *real* terms (constant prices) as opposed to *nominal* terms (prices at the time the goods or services are provided). That is, the impact of inflation is eliminated from the analysis because we are interested in costs and benefits in a common money value. The only time that we make *real* adjustments to prices over time is if the price of a particular good or service is expected to increase or decrease *relative* to all other goods and services. In such cases the relative change should be quantified and built into the analysis. Common examples where relative price changes may be relevant to the analysis are:

- high technology products for which prices are expected to fall in real terms eg, the very latest computer technology
- high technology products which become obsolete quickly and which are likely to be replaced with higher quality products, eg, health technology and defence hardware
- natural resources where supply is scarce or constrained eg, oil/petrol and electricity, and/or
- wages and other input prices that are expected to increase faster than the rate of general inflation.

134. A useful working rule is that we assume the cost of a good or service will remain constant in real terms (ie, before inflation) unless we are reasonably sure that its price will change relative to all other prices in the economy.

135. Product-specific cost inflation should be taken into account to the extent it differs from general inflation, and to the extent there is good evidence for it. Just because certain prices have risen every year for the last 10 years, doesn't necessarily mean that they will continue to do so. Indeed, it may often be reasonable to assume that they will revert to the long-term mean.

136. Undertaking a CBA in nominal terms is possible, but would require a different discount rate that is also expressed in nominal terms. CBAs that are calculated in nominal terms often lead to confusion for this reason.

Truly unquantifiable benefits

137. We have argued above that far more costs and benefits can be quantified than is normally thought, although confidence intervals may be large in some cases. Even a large confidence interval may convey useful information.

138. In some cases, however, the confidence interval of one cost or benefit may be significantly larger than those of the other costs and benefits, the analyst may be unwilling to invest in quantitative analysis or there may be a cost or benefit that is truly unquantifiable. In such cases, it may be appropriate to carry out a cost benefit analysis of the reasonably quantifiable costs and benefits, and set the result against the unquantifiable cost or benefit, as illustrated in the box below. This is sometimes called a ‘threshold analysis’, or a ‘backward analysis’. See the following example:

Example: National Monument

Quantified costs and benefits

Use of space for exhibitions	\$32 million
Construction cost	-\$30 million
Maintenance & operating costs	-\$10 million
Net Present Value	-\$8 million

Unquantified benefit

National identity benefit	√
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Assuming an inability to quantify one benefit, this CBA can be turned around by posing the following question to the decision-maker: Does the willingness to pay for this project’s contribution to national identity exceed \$8 million NPV, or (assuming an 8% discount rate) \$640,000 per annum?

Note that to be confident that this investment is socially optimal, it would still have to be compared with other possible uses for the money.

Equity (distributional) issues

139. Cost benefit analysis is not well suited to assessing equity (fairness) issues and impacts on social infrastructure. Where there might be concerns about how the benefits and costs fall on different groups of society, or how a project might impact on social infrastructure, the best approach is to draw attention to these issues in the narrative section of the report.

Step 5: Discount and compare costs and benefits

140. In all but the simplest proposals, costs and benefits should be identified for each year over the life of the project. In general, it is not appropriate to treat costs and benefits in one period as having the same weight as costs and benefits in other periods. Rather, they need to be *discounted* to a common point in time. The recommended discount rates change from time to time and can be found on the Treasury website <http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/currentdiscount rates>.

Discounting

141. The term *discounted* means that costs or benefits which occur later are given less weight than costs or benefits which occur sooner, with larger reductions the further into the future the costs or benefits occur. The *discounted value* of costs or benefits is therefore the relevant assessment measure. The discounted value is also known as the *present value*.

142. An intuitive justification for discounting is that most people would prefer receiving a dollar today over receiving a dollar in a year's time. This is referred to as *time preference* or *the time value of money*.

Example: Discounting – the rationale

A dollar today can be invested, say in a bank deposit at an interest rate of 5%, so that in a year's time it is worth \$1.05. Receiving \$1.05 in a year's time is therefore equivalent to receiving a dollar now.

143. To value the future receipt in today's terms, we *discount* the future receipt by the discount rate, which in the case of the example above is 5%.

144. The number by which we have to multiply the future value to obtain today's equivalent is called the discount factor, and is equal to

$$\frac{1}{(1 + \text{discount rate})^n}$$

145. Where n is equal to the number of years over which the value is being discounted.

146. A second, related, justification for discounting, and the one which is used in practice to derive the *discount rate* (*r*), is that when a person assesses a proposal, they will require a return at least as high as they can obtain from any other investment of equal risk.

147. By discounting, the net benefit or cost *over and above the return for other proposals of equal risk* can be determined. A net present value (NPV) above zero indicates a higher return than other proposals of equal risk, an NPV of zero indicates an equal return, and a negative NPV indicates a lower return.

Example: Discounting Using the Formula

If the discount rate is 10%, the discounted values of expected costs or benefits are calculated as illustrated in the following table:

Year (n)		0	1	2	3
Discount factor = $1 \div (1 + 10\%)^n$		1.000	0.909	0.826	0.751
Forecast costs or benefits		-100	45	45	45
Discounted values (value x discount factor)		-100	40.909	37.188	33.808
Present value (sum of discounted values)	11.906				

Discount rate

148. Discounting is one of the most controversial aspects of CBA and often has a bigger impact on the outcome than any other factor. This section explains why the Treasury's policy is to use a pre-tax discount rate equal to the long-run return on investments made by share-market companies.

149. The Treasury's rate is often considered to be high. It is said that it does not value future outcomes sufficiently, because future benefits are so heavily discounted. Because of the compounding effect, benefits that arise after 30 years or so have a relatively small effect on the project net present value (NPV) or the benefit-cost ratio (BCR) – less than 10% if there is a constant net benefit stream and the discount rate is 8%. It is said to encourage short-termism.

150. However, a useful way to think about the discount rate is as a hurdle rate of return, or as a project's internal rate of return. In making investments, the public policy objective must be to maximise the return that is obtained from the tax payer's dollar. By 'return' we mean the net total of the social and economic impacts of a project, or the benefits net of the costs, all valued at their opportunity costs.

151. The purpose of making investments is to generate future benefits. Assuming that all benefits have been valued correctly, we should be indifferent between one kind of benefit and another, if their value is the same. Or putting it the other way around, if people are indifferent between two different kinds of benefits, then they should be given the same value.

152. So assuming that benefits have been valued fairly, the government should be making investments where the value of the benefits is maximised. This approach ensures maximisation of future wealth (wealth should be interpreted broadly, to include financial, physical, natural, social and human capital).

153. One place where the government could invest is the share market. The government does, in fact, invest in the share market, in particular through the ACC and the New Zealand Superannuation Fund. It could also reduce tax rates and allow taxpayers to invest directly in the share market. If it is able to generate high returns that way, then why should it make investments that have a lower rate of return? Doing so would leave taxpayers and the nation worse off.

154. The following example illustrates the importance and role of the discount rate in decision-making:

Example:

Suppose we are comparing a \$100 investment in the share market (which is assumed to produce a rate of return of 8%) with a \$100 investment in an infrastructure project that has a lower rate of return (say 4%). Suppose further, for the sake of the illustration, that both produce a single benefit in 20 years' time:

- a) In the case of the share market investment, a single benefit in 20 years' time can be achieved by reinvesting dividends in the share market, and cashing out the total after 20 years. At 8%, the value of the \$100 investment in 20 years' time is worth \$466.
- b) In the case of the \$100 infrastructure, the value of the single benefit in 20 years' time is \$219.

Clearly, in this example the share market investment is superior to the infrastructure project because it provides a greater benefit.

The table below shows that both the NPV and the BCR of the share market investment is larger than the NPV and BCR of the infrastructure project regardless of the discount rate used:

Discount rate:	4%		8%	
	Infrastructure project	Share market investment	Infrastructure project	Share market investment
NPV:	\$36.92	\$112.68	-\$35.63	\$0.00
BCR:	1.37	2.13	0.64	1.00

If the infrastructure project were evaluated solely by reference to its NPV (or BCR) without comparing it to the next best alternative project, then under a 4% discount rate it would be deemed to be worth undertaking, even though this would be the wrong conclusion.

155. This example illustrates two things:

1. The actual choice of discount rate is often not so important in ranking projects, provided the same discount rate is used for all projects. The discount rate may, however, make a difference where the costs and benefits of different projects have significantly different time profiles.
2. However, using a lower discount rate is likely to mislead decision-makers because projects are usually evaluated without explicit evaluation of the share market counterfactual.

156. To avoid this outcome, this guide recommends the use of a discount rate that is based on the rate of return of the next best alternative investment. The most convenient ‘alternative investment’ is the share market. If this practice is adopted, then the NPV (or BCR) will be a reliable guide as to whether the project should proceed, without having to draw an explicit comparison with the next best alternative investment.

157. A high discount rate does not mean, of course, that long-lived investments won’t be made. It just means that they will be made less often, on the grounds that wealth and value can sometimes be generated more effectively in other areas. Decisions based on CBAs that fairly value benefits and employ a market-related discount rate are more likely to ensure that government investments are made where they produce the highest value to the nation.

158. A high discount rate also does not necessarily mean that intergenerational interests are ignored. Rather than trying to take into account the values of future generations, which are necessarily unknowable, by manipulating the discount rate, this guide takes the approach that CBA should take account of the preferences of the current population, which include preferences about sustainability and its legacy for future generations.

The discount rate for Public Private Partnerships (PPPs)

159. The Treasury provides separate guidance on the evaluation of PPPs. This guide draws attention to just one feature of PPPs, which is the consideration of risk in the discount rate used to compare bids against each other and against the ‘Public Sector Comparator’.

160. In a PPP, the Government buys a service as well as an asset. Payments reflect the service provided in every period including the repayment of private sector capital used to finance the construction of the asset. In a PPP evaluation, the net present cost of the

government financing and procuring the infrastructure using traditional methods is compared against the net present cost of payments to the private sector under a PPP contract. The discount rate used to compare the costs of PPP procurement against traditional procurement is usually lower than the discount rate used to compare the costs and benefits of the project as a whole because, in practice, under a PPP contract the private sector usually does not bear all of the project risks.

161. A key principle of PPPs is that project risks should be allocated to the party that can manage them most efficiently. For example, many of the risks relating to the development and long-term performance of the asset are transferred to the private sector. However, where the demand for the service is mainly influenced by government policy, a significant part of the demand risk for a project is usually retained by the Government.

162. To illustrate the effect of risk allocation on the discount rate, consider the following hypothetical scenarios.

- a At one extreme where the Government retains all risks, in other words where the Government guarantees all of the contractor's costs and guarantees the level of payments irrespective of the quality of service that is provided, the arrangement would be equivalent to a loan from the contractor to the government. It should be clear that in this situation, the arrangement should be evaluated like a loan and a discount rate equal to the Government borrowing rate should be used to compare bids against the Public Sector Comparator.
- b At the other extreme, where all risks are transferred, including the full demand risk, a fully risk adjusted project discount rate should be used (or, alternatively if required, the standard Treasury discount rate).

163. Because most PPPs do not transfer all project risk to the private sector, an intermediate discount rate needs to be chosen that reflects the extent of risk transfer achieved. The method for estimating this discount rate is described in the PPP guidance material. This ensures that the risks that private sector investors in the PPP are exposed to are taken into account when bids are evaluated against the 'Public Sector Comparator'.

164. Before attempting an evaluation of potential PPP projects, readers should refer to the Treasury's PPP guidance material and contact the Treasury's PPP Team.

Calculation of the NPV, BCR and/or MIRR

165. The objective of a CBA is to determine whether the benefits of making a decision exceed the costs, or if several alternatives are being evaluated, which produces the highest benefits relative to the costs. This is done by setting out on a spreadsheet the costs and benefits (ideally ranges) for each year, and discounting them to a common point in time. The result can be presented in several ways:

- The net present value (NPV) is equal to the sum of the discounted net benefits (or equivalently, the sum of the discounted benefits less the sum of the discounted costs).
- The benefit cost ratio (BCR) is the ratio of the sum of discounted benefits to the sum of discounted costs. Care is required to ensure that benefits and costs are properly allocated. For example, cost savings should not be deducted from the denominator but should be treated as a benefit and added to the numerator.
- The internal rate of return (IRR) is the discount rate that produces an NPV equal to zero. The IRR assumes that positive cash flows can be reinvested at the project's IRR rate.

This is often not plausible; given that the project discount rate recommended by this guide reflects the return that could be obtained elsewhere, a better approach is to use a modified internal rate of return (MIRR).

- The modified internal rate of return (MIRR) is calculated assuming the benefits and costs are financed or reinvested elsewhere in the market (i.e. at the recommended discount rate). MIRR provides a more realistic and more meaningful indicator of the rate of return to the investment than does IRR. Microsoft Excel includes a MIRR function that allows one to set both the finance and the reinvestment rate.
- Payback period which refers to the amount of time it takes for the proposal to recover its initial outlay and for the benefits to exceed the costs. This is a very simple but misleading form of cost benefit analysis. It does not measure the value of a proposal and should not be used.

166. Each of the NPV, BCR and MIRR measures has its advantages and disadvantages. BCR and MIRR provide a more intuitive understanding of the value of projects than NPV, especially where projects of very different sizes are being compared within a budget constraint. But they sometimes rank projects incorrectly. Consider the following table (which for illustrative purposes assumes a discount rate of 6%):

Projects → Year ↓	A	B	C	D	C'	D'
0	(\$10.0)	(\$10.0)	(\$10.0)	(\$20.0)	(\$10.0)	(\$20.0)
1	\$5.0	\$9.0	\$0.0	\$0.0	(\$100.0)	\$100.0
2	(\$9.0)	(\$5.0)	\$0.0	\$0.0	\$106.0	(\$106.0)
3	\$25.0	\$25.0	\$33.7	\$33.7	\$33.7	\$33.7
NPV	\$7.7	\$15.0	\$18.3	\$8.3	\$18.3	\$8.3
BCR	1.4	2.0	2.8	1.4	1.2	1.1
IRR	30%	58%	50%	19%	20%	269%
MIRR	19%	34%	50%	19%	12%	9%

167. Consider, for example, projects C and C'. These differ only in that the latter includes an investment of \$100 in period 1, which is withdrawn in period 2 and which returns 6%. In other words, because the opportunity cost is 6%, this investment neither adds value nor imposes an economic cost. Yet it reduces the BCR from 2.8 to 1.2, and the MIRR from 50% to 12%. The reason is that the net benefits of this project are averaged over a larger investment. The NPV measures the true contribution of the projects to economic welfare.

Monte Carlo Simulations

168. If the individual benefits and costs are represented by ranges rather than point estimates (the discount rate could also be represented by a range), then a Monte Carlo simulation will be necessary to calculate the confidence intervals for the project's NPV, BCR or MIRR. Appendix 1 describes what a Monte Carlo simulation is and how it is carried out.

169. Providing a range provides much more information to the decision-maker than a point estimate, because it not only conveys the 'best estimate' (which is often the mid-point of the range), but also the degree of uncertainty around the estimates. However, if the distribution of values is skewed, the 'best estimate' may not be the mean or mid-point of the distribution of values and should be reported explicitly.

Step 6: Assess the CBA: Is more research required?

How much to invest in a CBA

- The question of how much expense or effort is put into a CBA should itself be subjected to some kind of cost benefit analysis.

170. CBAs can be done on the back of an envelope or they can involve empirical research costing in excess of \$1 million. Thought needs to be given, therefore, to the kind of CBA that is appropriate in a given situation.

171. Indeed, a mini-CBA should be carried out for the CBA. What are the costs and benefits of carrying out a sophisticated CBA including field research, as opposed to a 'desk-top' CBA? The effort that is put into a CBA is likely to be proportional to the size of the project and to the scope for reducing uncertainty around the estimates.

172. Costs should be incurred in obtaining additional information on a project's costs and benefits so long as they are exceeded by the value of doing so. The value of a CBA arises from avoiding bad decisions. For example, if a project that seems worthwhile is found, after carrying out a CBA, to have an NPV of negative \$20 million, and the project does not proceed as a consequence of the CBA, then the value of the CBA is \$20 million. If a project that seems worthwhile is found, after carrying out a CBA, to have an NPV of \$20 million but another variant of the project is found to have an NPV of \$30 million, then the value of the CBA is \$10 million.

Who should do a CBA?

173. There are two answers to this question. The first is that all policy advice, that is to say all advice that is aimed at helping decision-makers make a decision, should adopt a CBA framework as an organising principle. It should provide information on how a decision would impact on the community at large, as well as on the extent to which it achieves decision-makers' objectives.

174. The second answer is that many government decisions impact on large numbers of people, justifying some investment in a systematic CBA.

175. Many government policy decisions have unique features that are not discussed in any CBA guide book. CBAs often require a good knowledge of economics, consideration of the issues from first principles, experience with other CBAs and practical knowledge of how to apply the various techniques discussed in this guide. Most government agencies will not have a sufficient flow of CBAs to justify the maintenance of sufficient in-house expertise to carry out a good quality CBA, and should therefore consider the engagement of outside consultants. The mini-CBA discussed in the previous section should provide the justification for the expense.

Step 7: Prepare final report

176. The report serves two functions:

- It **communicates** the results of the CBA. To be helpful to the reader, its centre-piece should be a summary cost-benefit table, which on one page sets out the main project alternatives, the main benefits, the main costs and the summary measures (NPV, CBR and/or MIRR), and includes notes that direct the reader to the place in the report where further information can be found on each cost or benefit. Instead of point estimates for the costs, benefits and summary measures, the table should set out ranges that reflect the level of uncertainty. A useful template for the summary cost-benefit table is provided below.

Where the benefits are exceeded by the costs, but there are significant unquantified benefits, it may be inappropriate to include a benefit cost ratio in the table. The decision-makers' attention needs to be drawn to the need for a 'backwards assessment', in other words an assessment of whether the unquantified benefits, net of unquantified costs, exceed the quantified negative NPV.

And most importantly, the report should also provide the intuition behind the results.

- It provides an **auditable record** of the way the analysis was conducted and the data sources.

Summary Cost-Benefit Analysis Table

\$m present value (PV) ranges in 2015/16 terms

Quantified Benefits	Notes	Option 1	Option 2	Option 3
Benefit 1	(1)	\$Range		
Benefit 2	(2)	\$Range		
Benefit 3	(3)	\$Range		
Etc				
Total		\$Range		
Quantified Costs				
Cost 1	(4)	\$Range		
Cost 2	(5)	\$Range		
Cost 3	(6)	\$Range		
Cost 4	(7)	\$Range		
Etc				
Total		\$Range		
Results				
Net of quantified costs and benefits – best estimate		\$Range		
90% confidence interval	(8)	\$Range		
Benefit/cost ratio – best estimate				
– 90% confidence interval		Range		
Unquantified Benefits				
Benefit 4	(9)			
Unquantified Costs				
Cost 5	(10)			

177. Where the NPV of the quantified elements is a negative number, ie, a net cost, the task of the decision-maker is to judge whether the value of the unquantified benefits (net of the unquantified costs) exceeds the net cost of the quantified elements. If the NPV of the quantified costs and benefits is a positive number, then the project is worth doing irrespective of the size of the unquantified benefits.

Part 2: Issues in Cost Benefit Analysis

CBA's limitations and common criticisms

178. CBA is a partial-equilibrium method. It typically measures direct or 'first-round' effects. It also typically assumes that all down-stream markets are perfectly competitive (although some CBAs, for example those of some transport projects, are starting to make an allowance for imperfect competition by estimating the increase in competition that is likely to result from the project) and that all prices equal marginal cost.

179. In many situations it will be quite reasonable to make these simplifying assumptions. However, the analyst must always exercise judgement as to whether there are good grounds for departing from these assumptions and make different assumptions.

180. Other limitations include the fact that all estimates of costs and benefits are based on uncertain forecasts, and some costs and benefits may be very difficult to estimate, or may not even be known. And as discussed above, CBA also typically measures willingness to pay rather than the impact on welfare.

181. These limitations can in some cases be quite severe, but they are not a reason not to use CBA. Other tools, such as multi-criteria analysis (MCA) are likely to be even worse (see discussion on page 52 and following), as is sole reliance on the decision-maker's intuition. If a decision-maker's intuition suggests a different estimate of costs or benefits, then rather than disregard the results of the CBA, the better course of action is to re-examine the analysis, test the assumptions, and if appropriate, seek an independent peer review.

Criticisms

182. This section sets out some common criticisms of CBA and explains why they are not generally a good reason not to do a CBA:

- "*CBAs produce false accuracy*": It is not unusual to see CBAs that state that the benefit cost ratio is "1.17". This is most likely to be spurious accuracy. The problem of false accuracy is overcome with the use of ranges.
- "*CBAs can't measure everything*": We acknowledge that there are some intangible benefits that the analyst won't be aware of or that are too hard to measure. As this guide explains, there are more benefits that can be measured than people think. As for those that can genuinely not be measured, this guide recommends that they should be drawn to decision-makers' attention along-side the results of the CBA of those benefits and costs that can be measured.
- "*CBA can be misused to produce self-serving analysis*": CBA is a tool, and like all tools it can be misused. This is not a reason to dismiss CBA in favour of some other tool.
- "*CBA is too complex*": This guide does not recommend that inexperienced policy analysts should carry out CBAs of complex or large projects themselves. Either a 'rough' CBA can be carried out, or the job should be contracted out to specialists. However, it is important for those carrying out CBAs to produce an accessible report that heeds the recommendations of this guide.

- *“Information requirements are often too onerous”*: CBAs can be carried out with whatever information is available. If the information is poor, then the confidence intervals will be larger. There are no other project evaluation methodologies that can produce better results from the same information base.
- *“CBAs overlook equity considerations”*: Equity is discussed on page 47, which recommends that equity implications of a project be discussed and drawn to decision-makers’ attention along-side the results of the CBA.
- *“The CBA is not likely to support our Minister’s objectives”*: This comment ignores the fact that public servants have two distinct roles. The first is to give ministers free and frank advice on what the likely consequences of their decisions are. A CBA is necessary for this role. The second is to implement the Minister’s decisions, whether or not those decisions are consistent with the advice given.

How CBA fits in with Government decision-making processes

The general decision-making process

183. When making decisions, ministers and other decision-makers principally want to know:

- What is the case for change, and how does a proposal fit in with their objectives (in a business case, this is the ‘strategic case’ - see <http://www.infrastructure.govt.nz/publications/betterbusinesscases>), and
- How does the proposal compare with alternative ways of solving the problem, including doing nothing, and what is its impact on economic growth and community well-being (this is the ‘economic case’).

184. They also want to know whether the proposal:

- Is affordable (the ‘financial case’), and
- Includes arrangements to ensure successful delivery of the project (the ‘commercial case’ and the ‘management case’).

185. The evaluation of the impact on economic growth and/or community well-being, and the evaluation of alternative projects, is essentially what a cost benefit analysis (CBA) is about.

Business Cases

186. For capital projects, the Government has developed a formal process called “Better Business Cases” (BBC) which provides the framework for testing the strategic, economic, financial, commercial and management cases. CBA is a step in the BBC process. See <http://www.infrastructure.govt.nz/publications/betterbusinesscases>

187. At the time of writing this, there is no Government requirement to follow the “Better Business Cases” process for projects that mainly involve operating expenditure. However, there is no reason why the process could not also be followed for large or risky projects that don’t involve significant capital expenditure, and indeed that would be good practice. For example, the ‘investment approach’ to social policy programmes encourages adoption of a business case approach.

188. In particular, given the desirability of evidence-based policy advice, a CBA should be carried out for all kinds of decisions, whether or not they involve capital projects, although the effort should be proportional to the size of the proposal.

Regulatory Impact Statements (RIS)

189. Cabinet requires all regulatory and legislative proposals to include a RIS that must be published. A RIS must include an analysis of the full range of economic, fiscal, compliance, social, environmental and cultural impacts, both positive and negative. In other words, it requires some form of CBA to be carried out, to the extent possible. See <http://www.treasury.govt.nz/publications/guidance/regulatory/impactanalysis>

Living Standards Framework

190. The living standards framework promoted by the Treasury has the following five elements:

- Economic growth (intended as a proxy for increases in overall economic welfare, which is what CBA tries to measure)
- Sustainability for the future (usually taken to refer to impacts on climate change, bio-diversity and loss of natural habitat, but can also refer to fiscal sustainability)
- Increasing equity (usually taken to refer to ensuring there is a safety net, to reducing income inequality and to achieving procedural fairness)
- Social infrastructure (refers to institutional structures and customs that underpin the way society works. They reduce the transactions costs of doing business, of securing one's income and property, and of social interactions)
- Managing risks.

191. The purpose of the framework is to ensure that policy advice takes into account impacts on broader aspects of living standards than are traditionally taken into account when assessing policy impacts¹². This means that advice to decision-makers should include a discussion of impacts on the above factors to the extent that the CBA has not already taken them into account.

How to do a rough CBA

192. Because almost inevitably, decision-makers will carry out a CBA in their heads if no formal CBA is available, advisors can help them organise their thoughts even with a rough or 'back-of-the-envelope' CBA, if it is done methodically and on paper. This part of the guide sets out the basic principles and the minimum steps that such a 'back-of-the-envelope' CBA should follow. A worked example is provided in appendix 2.

The roughest CBA

193. Preliminaries: Before embarking on the CBA, it is useful to

- Re-clarify the nature of the problem or opportunity that is being considered, and the decision that decision-makers will be asked to make.

¹² An alternative, systematic, approach based on 'subjective wellbeing' has been proposed by the Legatum Institute in the U.K. See O'Donnell et al (2014).

- Clarify whether the purpose of the analysis is to assess how the proposal fits in with decision-makers' objectives (in this case a multi-criteria analysis would be appropriate), or whether it is to assess how the proposal impacts on the public.

194. A CBA is appropriate if the purpose of the evaluation is to assess how the proposal impacts on the public. In almost all cases, it should be possible to do the following:

- Step 1:** Define the proposal, its alternatives and the counterfactual.
- Step 2:** Identify the people who gain and those who lose.
- Step 3:** Identify the benefits and costs and define them in concrete terms, i.e. in terms that have observable consequences. This should avoid the risk of double counting. It may also be possible to determine in which time periods they will occur.
- Step 6:** Determine whether it is worth investing in more research in order to quantify the costs and benefits (steps 4 and 5), and what the nature of that research should be.
- Step 7:** Write the report, including a summary CBA table with rows setting out the benefits and costs, and columns identifying the main proposal alternatives.

195. Together with the preliminary considerations, these steps provide useful information to a decision-maker, as they help to:

- understand the problem or opportunity and the possible solutions,
- by summarising them in a table on one page, put the expected benefits and costs into perspective, even if they have not been quantified,
- determine the nature of any research that may be required to undertake a fuller CBA with quantified costs and benefits, and
- determine whether carrying out a fuller CBA is justified.

The next level up

196. It is often possible to undertake:

- Step 4:** Quantify costs and benefits in terms of orders of magnitude, using ranges.
- Step 5:** Discount to a common period, compare benefits with costs.

197. In many cases such rough quantification can provide surprisingly useful information even if arrived at through introspection.

198. If there is a cost or benefit that really can't be quantified, then it should be included at the bottom of the CBA summary table (but with no quantification), so that it is not overlooked by the decision-maker.

199. See appendix 2 for an example of a 'rough CBA'.

Relationship to Gross Domestic Product (GDP)

200. Effects on gross domestic product (GDP) are often equated with effects on national welfare. However, GDP doesn't measure welfare. While GDP is often a useful proxy for national welfare, this is not always so. For example, GDP measures domestic production, irrespective of whether the benefits accrue to locals or foreigners. A macro-economic measure that better corresponds to national welfare is 'Gross National Disposable Income' (GNDI).

201. Another important difference between a welfare measure and what GDP measures is the treatment of non-market effects, such as externalities. These are not measured by GDP and can be considerable in some cases. An example of a negative externality is the increase in accidents that might be brought about by a new road.

Equity

- Where a project, proposal or option has significant distributional consequences, then these should be analysed in terms of the Government's wider distributional policies and drawn to decision-makers' attention.
- This generally needs to be done separately from the CBA, but should be referred to in the CBA summary table.

202. The purpose of CBA is to help decision-makers understand the welfare impacts of their decisions. Up to this point, this guide has measured welfare impacts in terms of the 'willingness to pay' concept. However, the application of the 'willingness to pay' concept suffers from two welfare-related limitations:

- a) Many public sector projects are of a kind where willingness to pay is not matched by an actual payment (eg, the provision of security services by the police) and where negative impacts (eg, the noise produced by a railway) are not accompanied by compensation.
- b) Welfare economics has long recognised that the marginal utility of income of different persons is not equal, that is to say that the benefit that a poor person derives from another dollar of income, and therefore from another dollar of expenditure, may be higher than the benefit derived by a rich person. Basing a CBA on the concept of 'willingness to pay' therefore reflects the existing distribution of income or wealth, which may be considered to be inequitable.

203. It is almost inevitable, therefore, that public sector projects have distributional consequences which some people will consider undesirable.

204. The UK Treasury Green Book recommends the inclusion of distributional weights in cost benefit analyses unless the analyst can justify not doing so. This guide does not recommend that,¹³ and instead recommends that where projects or options have significant favourable or unfavourable distributional consequences, that they be analysed separately in terms of their relationship to wider government distributional policies and drawn to decision-makers' attention.

¹³ Nor does the Australian Department of Finance Handbook of Cost Benefit Analysis 2006.

205. There are several reasons why using distributional weights does not seem a good idea. One is that different projects impact on different people differently, so that it is likely that each individual ought to be compensated in some cases, while in others the individual ought to be doing the compensating. Given the very large number of public sector projects that impact on individuals, it is likely that the net level of advantage or disadvantage to each individual is much smaller than the advantage or disadvantage arising out of a single project.

206. Another reason is that the distributional impacts of a given project are usually difficult to determine, not least because the final incidence of the benefit or cost may not fall on the people who are directly affected¹⁴.

207. Also, the tax/welfare system could be thought of as a wash-up compensation system that not only compensates for inequities and misfortunes of life such as disabilities and unemployment, but also compensates for any net disutilities as a result of public sector projects. While it does so imperfectly, it is difficult to determine whether it over-compensates or under-compensates in relation to any individual.

208. Nevertheless, while the tax/welfare system is the primary tool for redressing inequitable income or wealth distributions, there may be situations where a public sector project can contribute to a redistribution of income or wealth at a lower cost. It is therefore desirable to analyse these impacts and refer to them in the CBA summary table. Because of their considerable political importance in some cases, this seems preferable to burying them within the technical cost benefit analysis and running the risk that they are ignored or double counted.

209. Our recommended approach seems even more pertinent where the primary purpose of a project is distributive, for example whether low decile schools should receive a larger financial allocation, or whether special provision should be made for child health outcomes.

Standard values

210. Because of the difficulty and cost of estimating many values, it is convenient for some kinds of CBAs to have available standards values. An example is the values provided in the NZTA's 'economic evaluation manual' for the value of time for different kinds of road and public transport users, and the value of injuries. Two other important values provided by NZTA are the value of life and the cost of air pollution. These are outlined below. The Treasury has developed a range of standard values for social sector projects and these will be published on the Treasury's Cost Benefit Analysis website.

Discount rate

211. For the Treasury's current recommended discount rate, see <http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/currentdiscountrates>. For an explanation, see page 34.

Deadweight cost of taxation

212. CBAs should include a deadweight cost of taxation, equal to 20% of project costs that are funded from general taxation. For an explanation, see page 15.

¹⁴ For example, if a new road saves truck drivers time, then the benefit is likely to be passed through to the firms they work for and, if those firms operate in a competitive market, through those firms to the ultimate consumers in the form of lower prices.

Value of life

- The value of statistical life is estimated at \$3.85 million as at June 2013 and is indexed to the average hourly earnings (ordinary time).

213. A value that frequently needs to be estimated is the 'value of statistical life'. It is therefore useful to provide a standard value.

214. Many projects increase or decrease the risk to life. People's willingness to pay for taking on or avoiding risk can be estimated through revealed or stated preference methods.

215. By extrapolating from the willingness to pay or accept for a small change in risk, it is possible to arrive at an implied cost of a fatality (or value of life). This is a statistical device that is useful for CBAs where the change in the probability of fatalities may be known.

216. Viscusi, W Kip & Aldy, Joseph E (2003), undertook a survey of international studies into the value of life.

217. The Ministry of Transport undertook a willingness to pay (stated preference) survey in 1989/90, which established the value of statistical life (VOSL) at \$2 million in 1991¹⁵. This value has been indexed to average hourly earnings (ordinary time) to express the value in current prices, and stood at \$3.85 million in June 2013 (New Zealand Ministry of Transport, 2013). It is consistent with the international values found by Viscusi et al (2003), and is used in most evaluations of New Zealand transport projects as well as in some other kinds of evaluations.

Air pollution

- Health costs of air pollution are estimated at \$40 per person per year per microgram/m³.

218. Another useful standard value is the cost of air pollution. Air pollution can cause fatalities amongst people in very poor health. Damage is mainly caused by very small particles of less than 10 microns in diameter. These are referred to as PM₁₀. Epidemiological studies suggest a 0.101% increase in daily death rates (across the population as a whole) for a 1 microgram per m³ increase in PM₁₀.

219. Based on UK costs (assuming similar death rates and adjusting for New Zealand costs of life), the annual mortality costs in New Zealand have been estimated by the New Zealand Transport Agency at \$30 per person exposed per year per microgram/m³ increase in PM₁₀. This figure can be increased by 30% (based on US and French contingent valuation studies) to take account of poorer health amongst those who do not die, to give a total annual cost of \$40 per person per year per microgram/m³. By contrast, health costs of ground level ozone are believed to be an order of magnitude less. See NZTA (2013); Maibach, M., Banfi, S., Doll, C., Rothengatter, Prof. W., Schenkel, P. Sieber, N., Zuber, J., (2000).

¹⁵ Miller & Guria (1991).

Risk and uncertainty

220. Risk and uncertainty are two ends of a continuum: if we know the distribution of outcomes then we call it risk, if not then we call it uncertainty. In practice, the probability distribution around a cost or benefit estimate is seldom known with certainty, which means we are somewhere along that continuum. The distinction between these terms is therefore not so significant in most situations. In this guide the terms will be used interchangeably.

221. Because CBA may depend to a large extent on forecasting variable values, all costs and benefits are uncertain (or risky) to a degree. Uncertainty is best expressed in the CBA by using confidence intervals or ranges rather than point estimates.

Contingency sums

222. In estimating construction costs, it is common practice for engineers to include a 'contingency sum'. This may be done to offset optimism bias, or to avoid the need for additional budgetary approvals if the cost goes over budget, or for other reasons. There is no need to take account of contingency sums where point estimates represent the 50th percentile of a distribution of possible outcomes, or where confidence intervals are used.

Sensitivity analysis

223. Sensitivity analysis is the study of how sensitive the NPV, or the BCR, of a CBA is to the uncertainty in individual costs and benefits, and in the discount rate. The main purpose of a sensitivity analysis is to tell the analyst where to direct his or her efforts: further work may be warranted on estimating a particular cost or benefit if the degree of uncertainty around it is large and the NPV is particularly sensitive to it. The further work may enable the analyst to reduce the confidence interval around a cost or benefit.

224. One way of determining which costs or benefits most affect the NPV is to vary each one at a time, holding all other costs and benefits constant. If variables are correlated, they may need to be varied together.

225. If the confidence intervals have already been worked out, then they will give an immediate picture of the sensitivity of the NPV to a particular cost or benefit. The sensitivity analysis can be illustrated by way of a Tornado diagram which shows the 90% confidence intervals for the different costs and benefits, as well as for the discount rate. See the hypothetical transport example in figure 2. In that example, the 90% confidence interval for travel time savings is +/- \$226 million in present value terms (the point estimate of travel time savings is \$2,394 million NPV but this is not shown on the diagram)¹⁶. In other words,

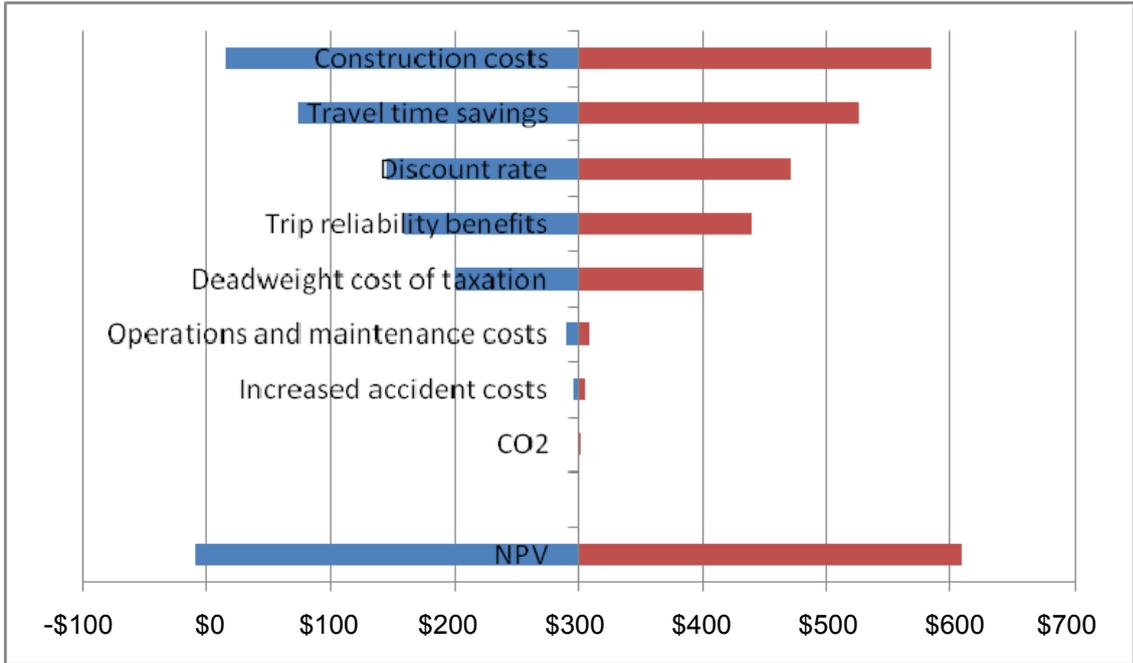
¹⁶ To produce the Tornado diagram for this hypothetical project, the following 90% confidence intervals were assumed:

- Travel time savings: +/- 20% initially, but the uncertainty grows by 8% each year.
- Construction costs, which are spread over three years, could vary by 10%, 12% and 14% in years 1, 2 and 3 respectively.
- The discount rate could be different by 12.5%, i.e. by one percentage point.
- Trip reliability benefits could vary by 20%.
- The deadweight cost of taxation could vary by 50%.
- Operations and maintenance costs could vary by 10%.
- Increased accident costs could vary by 10%.
- The value of CO₂ emissions could vary by the same percentage as the travel time savings.

reasonable differences to the travel time savings estimate could change the project NPV by +/- \$226 million. However, because the uncertainty in the travel time savings estimate is partly neutralised by uncertainty in some of the other estimates (see “Monte Carlo Simulation” below), the 90% confidence interval for the NPV of the project as a whole is less than the sum of the confidence intervals, only around +/- \$309 million in this example.

226. In this example, the NPV is most sensitive to uncertainty in the cost of construction, followed by uncertainty in travel time savings. The NPV is not very sensitive to uncertainty in operations and maintenance costs, accident costs and CO2 emissions.

Figure 2:



Source: Treasury

Point estimates

227. Despite the ‘more honest’ use of confidence intervals rather than point estimates, confidence intervals or ranges are more difficult to communicate in a public forum than point estimates. The mean of the distribution of estimates for benefits and costs, for net present values (NPVs) and for benefit cost ratios (BCRs) could therefore continue to be provided in addition to confidence intervals.

228. The mean of the distribution of possible values is sometimes referred to as the 50th percentile. In most cases the distribution is assumed to be a normal distribution, in which case the point estimate, mean or 50th percentile is the mid-point of the confidence interval.

Financing components

229. An offer to supply a product or service, or build an asset, sometimes includes terms for delayed payment. An offer that includes a delayed payment is equivalent to an offer that requires immediate payment, plus a loan from the seller to the buyer.

230. These two components should be evaluated separately. In order to do so, the seller should be asked to quote a price for immediate payment, as well as a price for delayed payment.

231. Where this is not possible, or the seller is unwilling, the loan should be assumed to be provided on the same terms as government stock issues of the same maturity. In other words, the price should be discounted to the date when the immediate price would be due using a discount rate equal to the yield on government stock of the same maturity.

232. Where an immediate payment (“pay now”) option is available, delayed payment options should always be rejected if the effective cost of finance is greater than the cost of government borrowing.

233. Note that in practice, it is most unlikely that a private sector supplier will be able to offer to the Government finance terms that are more favourable than the terms at which the government can borrow in wholesale markets. Finance leases, for example, are not generally attractive to Government for this reason. The only realistic exception is where the delayed payment terms benefit from some kind of subsidy provided by a foreign government, such as a tax concession or concessional export credit.

Alternatives to CBA

234. Sometimes it may be appropriate or sufficient to carry out a partial CBA. The following briefly describes such partial methods:

Multi-criteria analysis

- Multi-criteria analysis (MCA) should be used to show decision-makers how a project fits in with their objectives.
- A CBA should be used to show decision-makers what the economic impacts are on the nation.

235. Multi-criteria analysis (MCA), sometimes referred to as multi-criteria decision analysis (MCDA), is sometimes advocated as an alternative to CBA, particularly where some costs or benefits are difficult or impossible to quantify.

236. MCA is used to appraise and rank alternative policy options against a given set of objectives or criteria. There is no standard methodology, but it usually involves setting a list of success criteria (possibly reflecting public policy goals) and assigning weights to each criterion. The various project options can be assessed and scored (typically by a representative panel of stakeholders) against the criteria, with the assigned scores multiplied by the weightings, yielding a ranking of alternative options.

237. MCAs are configured either:

- as crude CBAs, particularly where it is difficult to quantify some of the costs or benefits and a qualitative assessment is required. This kind of MCA can be recognised by the fact that the criteria measure impacts on the population at large, or at least those people who are affected by the proposal or project,

or

- as evaluations of the extent to which proposals or projects meet the objectives of decision-makers. They can be recognised by the fact that the evaluation criteria, or at least some of them, relate to the policy interests of decision-makers rather than the specific impacts on members of the public, or indeed the economic effects on society at large.

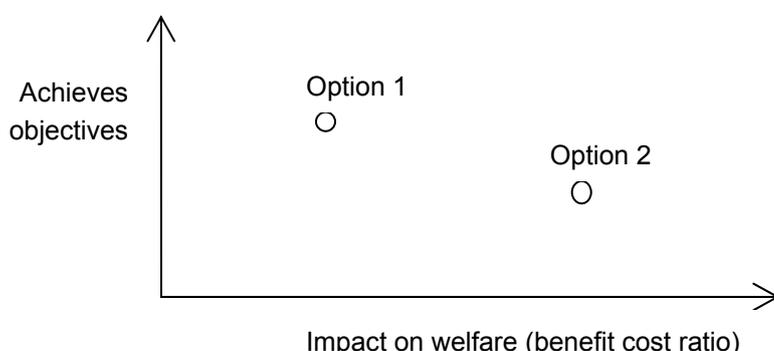
238. Both kinds of analysis have their place but there may be value in reserving the term “MCA” for the latter. An MCA of the latter kind is suitable for measuring “effectiveness”, ie, the effectiveness of a proposal or project in meeting stated objectives.

239. The first is really a rough kind of CBA and is employed because of limitations in data or time. Its short-comings usually include some of the following:

- Criteria are ill-defined and reflect decision-makers’ objectives rather than the impact on welfare.
- Criteria overlap, resulting in double counting.
- Different denominators are implicitly used for different criteria, which can result in ‘adding apples and pears’.
- Criteria are evaluated by decision-makers or their staff on an intuitive basis rather than empirically.
- The process for evaluating criteria and their weights often entails consensus building, which encourages ‘group think’.
- Cost is not given a 50% weighting. This can produce a bias towards more expensive options.
- “Do nothing” option is ignored. This can produce a bias towards action.
- No attempt is made to take the value of time into account.

240. Attempts should always be made to remedy these short-comings. The more this is done, the more the MCA will look like a conventional CBA. Thinking of the analysis as a CBA rather than an MCA will help minimise those shortcomings.

241. Decision-makers should always receive information on how different options contribute to welfare (ie, a CBA), but sometimes they also want information on how effective they are in meeting the decision-makers’ objectives (ie, an MCA). One possible way of displaying both types of information simultaneously is in two-dimensional space as follows:



Economic Impact Analysis

242. Economic Impact Analysis (EIA) differs from CBA in that it measures the economic impact of a project, that is to say the activity generated, rather than the net benefit created.¹⁷ Because it measures the activity generated, it treats costs as a benefit. Using an extreme example, if a project involved digging a hole in the ground and filling it in again, then the expenditure on labour employed would be treated as a contribution to the economy and therefore as a benefit. The cost would be ignored.

243. In contrast, a CBA would treat the expenditure on labour as a cost, recognising the fact that the labour is prevented from carrying out some other activity, ie, recognising its 'opportunity cost'. Even if the labour was idle in the absence of the project, it would at best be given an opportunity cost of zero. This is because while the expenditure on labour may be a benefit to those newly employed, there would be an offsetting dis-benefit to those who have to pay for this through the tax system.

244. EIA can provide useful contextual information for decision-makers, but it is not suitable as a tool for measuring the balance of costs and benefits of a decision to society.

General equilibrium analysis

- In most cases, a general equilibrium analysis does not capture any significant costs or benefits that a partial equilibrium analysis does not also capture. A partial equilibrium analysis is therefore generally sufficient.
- General equilibrium effects may need to be considered if the project causes significant economy-wide changes in prices.

245. CBA is a partial-equilibrium method. It typically measures direct or 'first-round' effects. Since a project changes the behaviour of both those who provide inputs as well as those who receive the benefits, who in turn influence the behaviour of their suppliers and customers, the question arises whether there might be costs and benefits elsewhere in the economy that flow from the project and that should be taken into account. Some macro-economic general equilibrium models include such 'multiplier effects'. However, in a CBA this is generally not done. As this is a frequent criticism of CBA, it is worth explaining why the standard CBA approach is generally appropriate, and when it isn't.

246. For example, some projects reduce the costs of businesses (eg, a road improvement reduces freight costs). If those businesses are operating in a competitive market, they will reduce their charges to their customers. The net effect will be that the businesses retain none of the benefit and pass all of it on to their customers, who in turn pass it on to their customers. The benefits may therefore ripple through the economy down to the ultimate consumers.

247. In this example, a CBA would typically assume that the businesses using the road derive all the benefit. But if markets are competitive and there are no significant general price changes, then it is reasonable to assume that this benefit is equal to the benefit that is derived by the ultimate consumers. There is no reason to think that the benefit 'multiplies' as it ripples through the economy. The size of the benefit is always the same and, in this example, equal to the reduction in freight costs.

¹⁷ See, for example, Dwyer and Forsyth (2009).

248. Similarly, a construction project increases the demand for construction materials which increases both the revenue and the expenditure of those who produce those materials. Should these second-round effects be taken into account?

249. CBA typically assumes that the increased activity from the project crowds out other activity. The total amount of activity in the economy does not change. The increased demand may lead to an increase in prices, but this is normally assumed to be very small, given that the project is likely to be small in the context of the whole economy.

250. Where a project is small enough relative to the economy not to bring about general price changes, general equilibrium modelling is unlikely to be a good substitute for a CBA. The models are not generally able to identify costs or benefits which a CBA can't identify. Although they can incorporate non-market values such as externalities, these have to be measured outside the model. The models are typically large, complex and therefore often not very transparent 'black boxes' whose output is difficult to verify. And most models are too aggregated to be able to pick up the effects of most individual projects.

251. Where a project is large relative to the economy and brings about significant general price changes, such as for example a reduction in import tariffs and a change in the terms of trade as a result of new foreign trade agreement, or the introduction of a carbon tax, then the change in prices can bring about changes in allocative efficiency throughout the economy. These are not easily captured in a partial equilibrium analysis, and a general equilibrium analysis is required.

252. When using a general equilibrium model, care needs to be taken regarding assumptions made about the opportunity cost of labour and the opportunity cost of capital. These are known as 'closure rules'. Care also needs to be taken to ensure that welfare benefits are measured (ie, GNDI or better still, 'equivalent variation') and not GDP.

Other forms of partial CBA

253. 'Cost utility analysis' and 'cost effectiveness analysis' are kinds of partial CBA that may be appropriate in situations where projects have to be ranked within a fixed budget and benefits can be quantified but not expressed in dollars (monetised). This technique is useful for comparing the ranking of different alternatives that have benefits that are measured in the same units. For example, if proposal A costs twice as much as proposal B, but has benefits that are more than twice as great, then proposal A is preferable to proposal B. An example is the practice of Pharmac, which estimates the benefits of pharmaceutical drugs in 'qalys'. A qaly equals the change in health-related quality of life multiplied by the change in quantity of life. Because of the fixed budget, it is sufficient for projects to be able to be ranked, and funded up to the point where the budget runs out.

254. CEA and CUA are typically used for ranking proposals within a given budget. They are not suitable for evaluating whether the budget should be spent at all or the size of the budget, because they do not contain measures that enable comparison with other kinds of projects outside the budget. They are unsuitable for comparing proposals that produce benefits that are measured in different dimensions, for example where one is measured in QALYs and the other in time saved.

255. Another form of a partial CBA is a financial analysis, or financial CBA. A financial CBA limits itself to measuring the financial impacts of a decision on an organisation or person.

256. Partial CBAs also include CBAs where only some of the costs or (more typically) benefits are estimated. For example, after estimating some benefits it may become apparent that a project is clearly worthwhile. In such situations, there may not be much value in trying to estimate the value of the other benefits that the project gives rise to.

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Acronyms

BCR	Benefit cost ratio
CAPM	Capital asset pricing model
CI	Confidence interval
CBA	Cost benefit analysis
CEA	Cost effectiveness analysis
CUA	Cost utility analysis
CGE	Computable general equilibrium
CUA	Cost utility analysis
DWL	Deadweight loss
GDP	Gross domestic income
GNDI	Gross national disposable income
IRR	Internal rate of return
MC	Monte Carlo, marginal cost
MCA	Multi-criteria analysis
MCDA	Multi-criteria decision analysis (= MCA)
MIRR	Modified internal rate of return
NPV	Net present value
PPP	Public private partnership
PV	Present value
QALY	Quality adjusted life years

Appendix 1: Monte Carlo Simulation¹⁸

257. This section describes what a Monte Carlo simulation is and how it is carried out.

258. A Monte Carlo simulation is a computer-based technique that uses statistical sampling and probability distributions to simulate the effects of uncertain variables on model outcomes. It provides a systematic assessment of the combined effects of multiple sources of risk (represented by the confidence intervals) in each of the costs and benefits and can also allow for known correlations between these variables.

259. The first step is to estimate 90% confidence intervals and probability distribution for each cost and benefit. In many cases, it will be reasonable to assume a normal distribution.

260. A Monte Carlo simulation can be run by Excel and many other programs. The program randomly generates thousands of possible values for each variable, based on the estimated confidence interval and type of probability distribution. The computer then calculates a probability distribution for the outcome (eg, the net present value of NPV).

261. To make a Monte Carlo simulation of a normally distributed variable in Excel, we use this formula:

=norminv(rand(), mean, standard deviation)

262. So if the mean is 15 and the 90% confidence interval is +/-5, then the formula for the variable is:

=norminv(rand(), 15, (5/1.645)¹⁹)

263. Suppose you enter this formula on cell A1 in Excel. To generate (say) 10,000 values for a particular cost or benefit, (1) copy the contents of cell A1, (2) enter "A1:A10000" in the cell range field to select cells A1 through A10000, and (3) paste the formula into all those cells.

264. Now follow this process in other columns for the other variables, including columns for the discount rate factors for each year. Then insert columns to calculate the net present value (NPV) and benefit-cost ratio (BCR) formulas for each row.

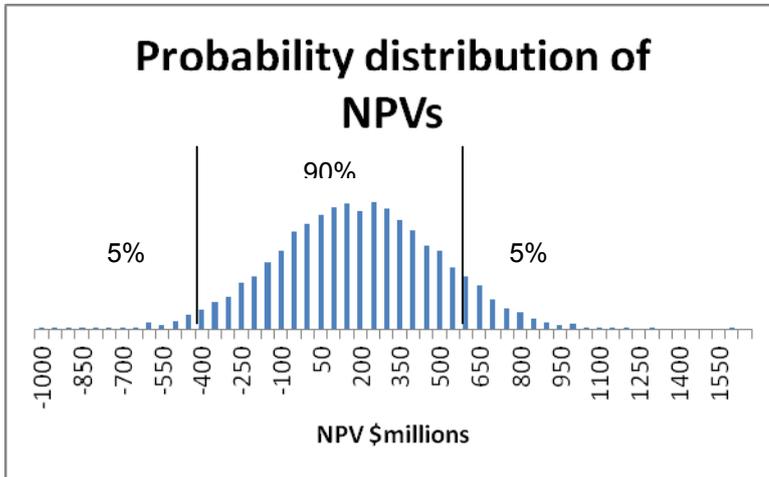
265. We can now work out the 90% confidence interval for the NPV (the same approach is used for the BCR). Use the STDEV formula to work out the standard deviation. The 90% confidence interval is equal to the mean of the numbers in the NPV column (use the AVERAGE formula) plus or minus the standard deviation times 1.645.

¹⁸ Adapted from http://lesswrong.com/lw/i8n/how_to_measure_anything/

¹⁹ The 90% confidence interval is equal to 1.645 standard deviations from the mean in each direction. In this example the 90% confidence interval is 15 +/- 5. The standard deviation is therefore 5/1.645.

Example:

Suppose the Monte Carlo analysis results in a mean value for the NPV of \$173 million, with a 90% probability that it lies within the range of -\$327 million to \$673 million. We can make a histogram (see below) to show how many of the 10,000 scenarios landed in each \$50 million increment (of NPV). This is more informative, and tells us a great deal about the distribution of risk and benefits we might incur from investing in this project.



266. The simulation concept can (and in high-value cases *should*) be carried beyond this simple Monte Carlo simulation. One improvement would be to learn how to use a greater variety of distributions (aside from the normal distribution). Noting that the main weakness of the above approach is that it assumes that variables are uncorrelated, another improvement would be to generate correlated random numbers or to model what the variables have in common. Cheap software packages are available that allow complicated correlation structures and a wide range of distributions in addition to the normal function (e.g. rectangular, triangular, lognormal, etc.).

Appendix 2: Example of a ‘Rough’ CBA

Proposal to impose a minimum price on alcoholic beverages

267. Suppose there was a proposal to impose a minimum price on alcoholic beverages, for example \$1 per standard drink of alcohol, or to increase the excise duty on alcohol, and we want to do a back-of-the-envelope CBA (a fuller CBA was carried out by the Ministry of Justice (2012). That CBA is described and summarised in appendix 3).

Roughest CBA

Description of the proposal and alternative options

268. As outlined in Part 2 of this guide, the first step is to clarify what exactly the proposal is and what the alternatives are.

- In this case the proposal is clear enough. \$1 was chosen because that impacts on the cheaper kinds of drinks but not on medium or high priced drinks.
- Apart from ‘do nothing’, the other main obvious alternative is to increase the excise tax on alcohol. We might consider a 50% increase in the excise tax.

Who are the gainers and losers, and what are the costs and benefits

269. The general approach adopted here is to ignore the benefits and costs to the alcohol abuser, on the grounds that at the margin they are equal to each other. Only impacts on ‘other people’, including the government as representative of taxpayers, are taken into account. We conclude that the gainers are the following:

- victims of alcohol-induced harm
- general taxpayers who have to contribute less towards the costs of alcohol-induced crime
- general taxpayers who will have to contribute less to health services (or who will be able to enjoy enhanced services as a result of the savings)
- general taxpayers who will benefit from an increased income tax contribution if the policy leads to improved workplace productivity of alcohol abusers²⁰
- the rest of society who may benefit from increased voluntary work provided by some people who would not do so if affected by alcohol
- under a regulated minimum price, the alcohol industry will initially get more revenue and profits. However, it seems reasonable to assume that those profits will quickly be competed away through product enhancements. It therefore seems reasonable that this benefit is close to zero.

²⁰ Transfer payments such as taxes are normally excluded in a CBA, but in this case we assume that in their private benefit cost calculation, alcohol abusers do not take into account the after-tax component of the increased workplace productivity that results from reduced alcohol consumption. It therefore needs to be recognised here as a real resource benefit.

270. The losers are:

- Alcohol consumers who will lose some 'consumer surplus' (refer to the diagram in figure 3 below), including the health benefits that may result from a modest level of consumption. Note that the diagram in figure 3 shows that much of the lost consumer surplus is in fact transferred to either the government or the industry. The net loss in consumer surplus is therefore only the deadweight loss triangle.
- The alcohol industry who may have to write off some plant that may become surplus to requirements as a result of the drop in demand.

271. Construction of the above list of gainers and losers, or a list of benefits and costs, requires some care in order to ensure that we are measuring welfare impacts and not conformity with decision-makers' objectives, to ensure comprehensiveness and to avoid double counting. We can therefore construct a benefit cost table as follows:

Cost benefit summary table

\$m present value (PV)

Benefits	Notes	Option 1 Minimum price	Option 2 Increase in excise duty
Reduction in alcohol-related harm to victims (including crime, traffic and domestic victims)	(1)		
Reduction in the govt's cost of crime (a gain to taxpayers)	(2)		
Reduction in cost of govt health and welfare services (a gain to taxpayers)	(3)		
Tax from increased workplace productivity (a gain to taxpayers)	(5)		
Value of increased voluntary work	(6)		
Increased profits for alcohol industry	(7)	nil	nil
Total			
Costs			
Loss in consumer surplus (all drinkers)	(8)		
Alcohol industry loss of value	(9)		
Total			
Results			
Net present value			

Assessment

272. A first glance at the above table might lead one to conclude that the benefits of imposing a minimum price or increasing the excise duty surely outweigh the costs. However, some reflection will tell us that the benefits depend on two crucial factors, the responsiveness of alcohol abusers to price changes and the influence that different levels of alcohol consumption has on people’s behaviour. For example, if alcohol abusers were very price-unresponsive but moderate drinkers were not, then the impact of a minimum price on the harm caused by alcohol could be small compared with the loss in consumer surplus. This suggests caution before jumping to conclusions about the effectiveness of such policies, and underscores the value of research that reveals the behavioural responses.

One level up

273. The thoughts in the previous paragraph could be used to develop and consider scenarios in order to determine in what situations the benefits might outweigh the costs, as follows:

	Benefits			Costs		Net
	Reduction in harm and govt’s costs of crime, health and benefits	Tax from increased workplace productivity	Increase in voluntary work	Loss of consumer surplus	Industry plant write-off	
Scenario 1: alcohol abusers are unresponsive to prices (minimum price).	Small	Small	Small	Medium	Small	Likely negative
Scenario 1a: alcohol abusers are unresponsive to prices (excise tax).	Small	Small	small	Medium-large	Small	Likely negative
Scenario 2: alcohol abusers are responsive to prices and prefer cheap alcohol (minimum price).	Large	Medium	Small	Medium	Small	Likely large positive
Scenario 2a: alcohol abusers are responsive to prices and prefer cheap alcohol (excise tax).	Large	Medium	Small	Medium-large	Small	Likely medium positive
Scenario 3: alcohol abusers are responsive to prices but drink a mix of cheap and expensive alcohol ²¹ (minimum price).	Medium	Small	Small	Medium	Small	Likely small positive
Scenario 3a: alcohol abusers are responsive to prices but drink a mix of cheap and expensive alcohol (excise tax).	Large	Medium	Small	Medium-large	Medium	Likely medium positive

²¹ Same as the rest of the drinking population.

274. The table suggests that:

- a) if alcohol abusers are unresponsive to prices, then the proposed policies are likely to be ineffective
- b) If they are responsive to prices, then either policy would be effective
- c) if they are responsive to prices and predominantly drink cheap alcohol, then a minimum price policy would be more effective
- d) if they are responsive but drink the same kind of alcohol as the general population, then an excise duty is more likely to be effective than a minimum price.

Two levels up

275. A further improvement to the rough CBA can be made by using available empirical data to the extent possible and making plausible assumptions about data that does not exist. This is illustrated here in respect of the two benefits in the cost benefit summary table above that appear to be the most important (i.e. reduction in harm to victims and reduction in the cost of crime to the government), and in respect of what appears to be the most important cost (loss of consumer surplus).

Cost of crime and road accidents

276. To determine the savings from less crime and fewer road crashes as a result of reduced harmful alcohol consumption, one needs to estimate:

- a) the proportion of events before the policy is implemented that is attributable to harmful alcohol consumption
- b) the extent that alcohol consumption is likely to fall as a result of the policy (ie, the price elasticity of demand for alcohol)
- c) the cost of events averted to derive an estimate of savings from reduced harmful alcohol consumption.

277. The savings from reduced harm as a result of alcohol consumption is equal to the product of (a), (b) and (c).

278. Data for (a) are available from Police statistics and from the 2009 New Zealand Crime and Safety Survey and the 2007 Business Crime pilot study, and are summarised and discussed in Ministry of Justice (2012), sections 6.1 – 6.3. The total number of harm events, as reported in table 13, is 4.1 million. The proportion of these events that is attributable to alcohol consumption is 18% (simple arithmetic average of the proportions set out in tables 16 and 17).

279. No New Zealand data is available for (b). To make the calculation manageable, we make the simplifying assumption that (b) is the same for all levels of consumption (ie, the consumption of heavy drinkers or binge drinkers falls by the same proportion as the consumption of light drinkers). We make the further assumption that it is equal to somewhere between 0% and 10% for a minimum price of \$1, and between 0 and 20% for an increase in the excise tax of 50%. We do the modelling on the seemingly plausible assumption of a 10% or 20% fall in consumption, respectively.

280. Estimates of both private and government costs (c) are available for different event types and are presented and discussed in section 6.5 of Ministry of Justice (2012). Total government costs are estimated as \$226 million (from p.54) and private costs as \$11.5 billion (from tables 13 and 19). The average cost per event is therefore just under \$3,000. However, it is well recognised that the private cost of harm from alcohol abuse, as well as from crime in general, is likely to be significantly higher than the reported cost. For the purposes of this CBA we assume that it could be as high as twice as much as the measured cost, ie, \$452m government cost and \$23bn private cost.

281. With the above information we can estimate that the total government and private cost of crime and accidents that would be saved under a minimum price policy is as follows:

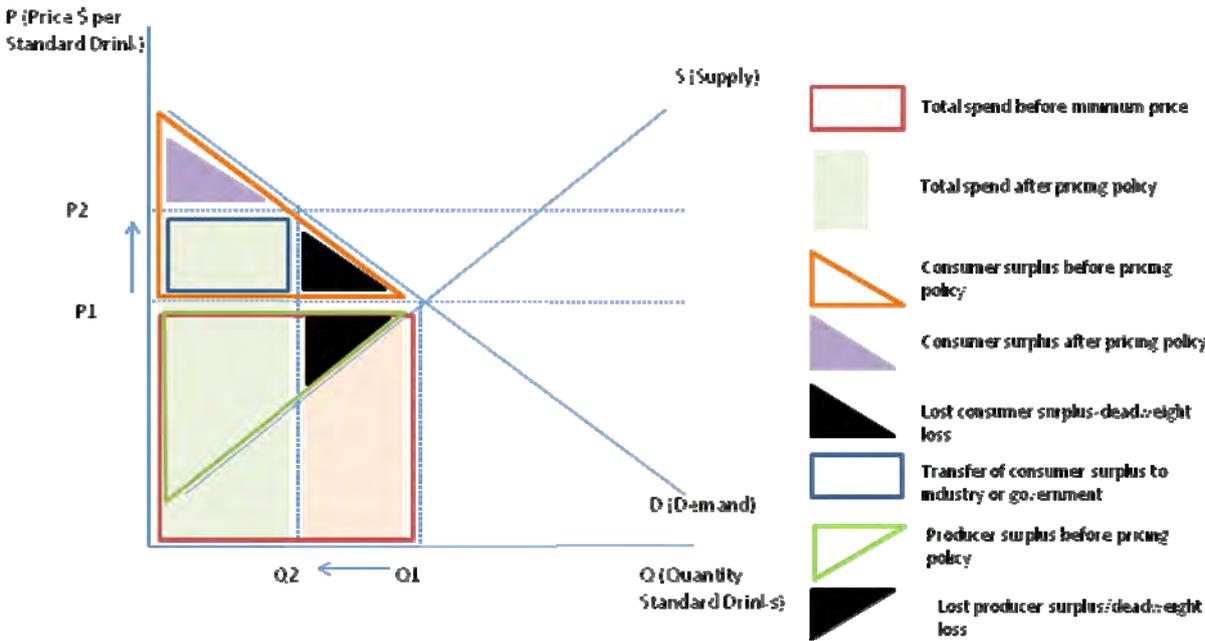
	(a)	(b)	(c)	(a)x(b)x(c)
Minimum price				
- reduction in private harm	18%	0-10%	\$23 billion	= \$0-414m
- reduction in government cost	18%	0-10%	\$452 million	= \$0-8m
Total				= \$0-422m
Increase in excise tax				
- reduction in private harm	18%	0-20%	\$23 billion	= \$0-828m
- reduction in government cost	18%	0-20%	\$452 million	= \$0-16m
Total				= \$0-844m

282. This compares with the Ministry of Justice (2012) finding of alcohol-induced crime or accident cost of \$61 million p.a. in the case of a minimum price policy, or \$450 million p.a. in the case of an 81% excise tax increase (see table 4), noting that the Ministry of Justice (2012) figures do not include the cost of unreported harm.

Loss of consumers' surplus

283. The concept of consumers' surplus is illustrated below:

Figure 3



Source: Ministry of Justice (2012), figure 12 on p.70.

284. As suggested in the illustration, part of the lost consumers' surplus is transferred to government in the case of an excise tax, or to the alcohol industry in the case of a minimum price. In the former case the transferred consumers' surplus benefits taxpayers, and can therefore be ignored. In the latter case it seems reasonable to assume that the industry will compete that profit away in the form of product enhancements. That part of the consumer surplus is therefore transferred back to consumers. The truly lost consumers' surplus is therefore the black area, referred to as the consumers' surplus deadweight loss. This is the value that we want to estimate.

285. Making the further simplifying assumptions that the supply curve is horizontal and the demand curve is a straight line, the deadweight cost resulting from the loss in consumer surplus is half of $(Q1-Q2) * (P2-P1)$.

286. We make the following assumptions:

	Minimum price	Excise duty
Q1 =	237,000,000	237,000,000 standard drinks ²²
Q2 =	213,000,000 – 237,000,000	190,000,000 – 237,000,000 standard drinks ²³
P1 =	\$0.80 ²⁴	\$1.50
P2 =	\$1.00	\$1.76 ²⁵

287. The loss in consumer surplus is between zero and around \$2,400,000 p.a. in the case of a minimum price, or between zero and \$6,110,000 p.a. in the case of a 50% increase in excise duty.

288. This compares with an estimated consumers' surplus deadweight loss of \$3.4 million p.a. in Ministry of Justice (2012, see table 32 on p.93).

²² This is an assumed 10% of the total amount of alcohol consumed in New Zealand. It coincides with the evidence provided in Ministry of Justice (2012) in table 8 on p.25.

²³ Making the assumption that the policy will cause consumption to drop by between 0 and 10% (minimum price) or between 0 and 20% (excise duty).

²⁴ Assumed average price per standard drink of all alcohol sold for less than \$1.00. A better approximation could be obtained by a quick survey of bottle store sales of low price liquor.

²⁵ Assuming an excise duty of \$51 per litre of alcohol, or 51c per standard drink.

Summary

289. With this information, we can put together a CBA summary table as follows:

Cost benefit summary table

\$m annualised values

Quantified Benefits	Notes	Option 1 Minimum price	Option 2 Increase in excise duty
Reduction in alcohol-related harm to victims (including crime, traffic and domestic victims)	See para 297	\$0-414m	\$0-828m
Reduction in the govt's cost of crime and accidents (a gain to taxpayers)	See para 297	\$0-8m	\$0-16m
Increased profits for alcohol industry	See para 285, last dot	nil	nil
Total		\$0-422m	\$0-844m
Quantified Costs			
Loss in consumer surplus (all drinkers)	See para 303	\$0-2.4m	\$0-6.1m
Total		\$0-2.4m	\$0-6.1m
Results			
Net of quantified costs and benefits – 90% confidence interval	See para 306	\$0-420m	\$0-838m
– best estimate		\$210m	\$419m
Benefit cost ratio			
– 90% confidence interval		1 – 352	1 – 138
– best estimate		176	69
Unquantified Benefits			
Tax from increased workplace productivity (a gain to taxpayers)			
Value of increased voluntary work			
Unquantified Costs			
Alcohol industry loss of value			

290. Note that both the reduction in harm and the loss in consumer surplus depend on the responsiveness of drinkers to price changes. They are likely to be highly correlated. Monte Carlo analysis should incorporate this correlation in sensitivity analysis of the range of net benefits.

Conclusion

291. In summary, the rough CBA above suggests that the benefits of both a minimum price policy and of an increase in the excise tax would outweigh the costs by a large margin.

292. An important uncertainty is around the price elasticity of demand, that is to say the responsiveness of drinkers to price changes. This was also identified as the main uncertainty in Ministry of Justice (2012). Because the price elasticity impacts on both benefits and costs similarly, different assumptions about the price elasticity should not make much difference to the conclusion that benefits exceed costs. Even in the extreme case where drinkers were nearly unresponsive to price changes, then both the benefits and the costs would be close to zero, but benefits would still exceed costs.

293. However, if the price elasticity of alcohol abusers is significantly lower than that of moderate drinkers, then the benefits would be smaller relative to the costs. While it seems plausible that this is so, our 'rough' CBA suggests that the difference in elasticity would need to be quite significant to overturn the conclusion that the benefits exceed the costs.

294. There are a number of other serious limitations in the above analysis. For example, in this analysis all crime and accident 'events' were averaged and treated as equivalent.

295. A more sophisticated CBA would also take into account, amongst other things,

- differences in the amount of harm caused by moderate and heavy/binge drinkers
- differences between males and females in drinking habits and propensity to cause harm
- differences between different age groups
- differences between types of alcohol
- cost and frequency differences between different kinds of harm (ranging from disorderly behaviour to traffic accidents, prolonged family violence and murder)
- The impact on workplace productivity
- The impact on community service

296. The analysis in Ministry of Justice (2012) tackled most of the above points. The results of our rough analysis are not very dissimilar and illustrate the power of doing a rough CBA. Nevertheless, the magnitude of the social costs and benefits at stake here suggest that research into some of the elements in the previous paragraph are well worth the while.

References

Ministry of Justice (2012), *The Effectiveness of Alcohol Pricing Policies*, <http://www.justice.govt.nz/publications/global-publications/e/the-effectiveness-of-alcohol-pricing-policies>

Appendix 3: Example CBAs

297. This appendix describes two CBAs to illustrate some of the difficulties encountered in estimating costs and benefits and some of the methods used to overcome them.

Bid to host the 2018 Commonwealth Games in Auckland

Summary

\$m NPV

Quantified Benefits	Notes	Option 1 Minimum price
New Zealand attendees	(a)	\$71m
Induced tourism	(b)	\$22m
“Halo” effects ²⁶	(c)	\$105m
Infrastructure	(d)	\$930m
Television revenue	(e)	\$60m
Sponsorship, etc	(f)	\$45m
Total		\$1,232m
Quantified Costs ²⁷		
Bid budget	(g)	\$21m
Infrastructure	(g)	\$930m
Operating costs	(g)	\$835m
Other capital	(g)	\$160m
Total		\$1,945m
Results		
Net present value		-\$713m
Benefit cost ratio		0.63
Unquantified Benefits		
National pride	(h)	
International profile	(h)	
Business opportunities	(h)	
Social, cultural and community (incl volunteering)	(h)	
Sports development	(h)	
Event culture	(h)	
Physical regeneration	(h)	
Unquantified Costs		
Congestion externalities	(h)	
Risk	(h)	

²⁶ Sense of enjoyment from hosting the CWG

²⁷ These include a 20% deadweight cost for taxpayer-funded expenses, as recommended in the Treasury's CBA primer.

298. The CBA was undertaken by LECG (now trading as Sapere Research Group) with input from Covec Ltd and NZIER in 2009/10. The CBA applied a discount rate of 8% pre-tax, real.

Analytical issues

299. Counter-factual: a lot of care was taken to separate those events and effects that were attributable to staging the event, from those that would occur anyway, or that were not necessary to stage the event.

300. A 4% discount rate was tested, but was found to have only a negligible effect on the benefit-cost ratio.

301. A national rather than a regional perspective was taken, and foreign consumers were not given standing.

Other

302. A computational general equilibrium (CGE) analysis was carried out. This captured flow-on benefits and costs of the spending on infrastructure, running costs and increased tourism related to the games. It incorporated displacement effects and resource constraints, and the phasing of expenditure and debt repayment. It found that the games generate strong positive benefits for Auckland over the course of the games development, as well as net gain over the long term. However at the national level, the games generate positive benefits in the short term as expenditure on construction and by tourists boost the economy, but result in a welfare loss in the long term, as funding is repaid. This reinforces the conclusion of the cost benefit analysis, although it should be noted that the CGE does not capture some of the quantified benefits in the cost benefit analysis (such as the 'halo' effect), and none of the unquantified benefits and costs.

Notes

303. Benefits estimation

- a The report referred to this as "in-person spectacle" (mainly ticket sales): to determine the consumer surplus, a demand curve was assumed based on an estimate made in a CBA of the 2010 Vancouver Winter Olympics.
- b Tourism/visitation impacts: Specific modelling work was undertaken using case study material from Melbourne 2006 and 'business as usual' modelling of Auckland-specific visitation patterns. An economic impact analysis was carried out which was then translated into a cost-benefit framework. Account was taken of displacement effects ('crowding out' of usual tourists/visitors) and the effect of expected price changes.
- c 'Halo' effect: This is known in the literature as an existence (or non-use) value. In general, stated preference valuations are used to determine existence values, again using the concept of willingness to pay. However, this was not done. Instead, results of contingent valuation surveys carried out in London, Manchester and Glasgow to measure willingness to pay for the London Olympics were used as a starting point, and adjusted for the New Zealand context. This is referred to as the 'benefit transfer' method. Benefit transfer methods are highly problematic, as discussed in this guide, so the study should have included some discussion of the validity of those surveys. Moreover, it is not clear how some of the adjustments were arrived at. For example, it was assumed that Auckland citizens would pay at most around half of what London citizens said they would pay to host the Olympics, but no explanation is given for why this should be so.

- d Infrastructure benefits: The report noted that
- o many new road infrastructure projects in New Zealand have expected benefit-cost ratios in excess of 1
 - o most infrastructure required for the games is not roads, and
 - o the only infrastructure that would not have been built anyway is infrastructure that in the period after the games, or in the absence of the games, would likely have benefit-cost ratios of less than 1.

The report therefore assumed that on average, benefit-cost ratios of infrastructure are equal to 1, with a high scenario of 3.15 and a low scenario of 0.5.

- e Television spectacle: most of the benefits of being able to watch the games on television were assumed to go to foreigners, which have no standing in this analysis. Also, the benefit to New Zealanders of watching the games on television was not counted, on the grounds that they would get that benefit regardless of where the games were held. That benefit could therefore not be attributed to holding the games in New Zealand. The value of the televised spectacle is equal to the revenue derived by the host. However, the report provides no information on how the figure of \$60 million was worked out: it appears that it represents an estimate made by the Central/local Government Bid Feasibility Group.
- f Sponsorship income: the \$45 million is based on an estimate made by the Bid Feasibility Group.

304. Costs estimation

- g Infrastructure and other costs were obtained from the Central/local Government Bid Feasibility Group's estimates. It appears that no assessment was made of whether there was an optimism bias.

305. Unquantified costs and benefits

- h Unquantified benefits: the report discussed these at length. For many of these, it concluded that the benefits were transient or ephemeral, or constituted double counting of other concepts (for example, national pride at least partly overlaps with the 'halo' effect).

The Effectiveness of Alcohol Pricing Policies

Summary

\$m changes in first year²⁸

Quantified Benefits	Notes	Min. price \$1.00	Min. price \$1.20	Excise ↑ 82%	Excise ↑ 133%
Increase in excise tax revenue due to rate increase	(a)			\$717	\$1,066
Partially offset by reduction in excise tax revenue due to quantity decrease	(b)			-\$84	-\$137
Reduced alcohol-related health costs	(c)	\$11	\$23	\$83	\$129
Reduced alcohol-related crime costs	(d)	\$45	\$94	\$332	\$516
Reduced alcohol-related workplace productivity costs	(e)	\$9	\$19	\$60	\$95
Total		\$65	\$136	\$1,108	\$1,669
Quantified Costs					
Loss of consumer surplus	(f)	\$90	\$180	\$763	\$1,188
Partially offset by transfer of consumer surplus to industry	(g)	-\$86	-\$167		
Loss of industry asset value	(h)	\$1	\$2	\$6	\$10
Reduced excise tax revenue	(i)	\$18	\$35		
Total		\$23	\$50	\$769	\$1,198
Results					
Net benefits		\$42	\$86	\$339	\$471
Benefit cost ratio		2.8	2.7	1.4	1.4
Unquantified Benefits					
Reduction in harm accruing to people other than the drinker	(j)				
Impact on alcohol on volunteering	(k)				
Unquantified Benefits					
Reduction in harm accruing to people other than the drinker	(j)				
Impact on alcohol on volunteering	(k)				
Unquantified Costs					

²⁸ This is a version of Table 3 in the study. It differs in that it omits a couple of intermediate options, classifies increased excise tax income to government (a) as a benefit rather than as a negative cost and re-labels some of the costs and benefits to make them more explicit. We have also added a row setting out the benefit cost ratios.

306. This CBA was undertaken by the Ministry of Justice and was published in early 2014. It analysed the impact and effectiveness of a regulated minimum price per standard drink of alcohol²⁹ in reducing harmful alcohol consumption.

307. The study attempted to ascertain the most effective minimum price from the point of view of maximising social welfare (ie, social and economic benefits minus social and economic costs) and also investigated how a minimum price compared with an increase in the excise tax.

308. The study can be found here: <http://www.justice.govt.nz/publications/global-publications/e/the-effectiveness-of-alcohol-pricing-policies>.

Notes

309. Benefits estimates:

- a Transfer to government: An increase in excise tax results in increased revenue for government, as well as increased revenue from increased sales of beverages to which consumers switch as a result of the relative price changes (eg, high priced beer, wine and spirits). The loss of revenue as a result of the reduced quantity consumed is accounted for separately in line 6.
- b Reduction in excise tax: Because demand for alcohol is not completely inelastic, both an increase in price and an increase in excise duty result in a reduction in quantities consumed and therefore government revenue.
- c Health effects: changes in hospitalisation, specialist treatment, Accident Compensation Corporation (ACC) and drug treatment costs to Government were counted.

The threshold for harms was assumed to start from 6 standard drinks per day (chronic harms) or per drinking occasion (acute harms).

Alcohol-related health harms were modelled in some detail to take into account the probabilities of contracting different kinds of health risks depending on age, sex and type of drinker. Data was sourced partially from the Sheffield study and partly from Dept of Statistics and Ministry of Health sources.

- d Reduction in crime costs: This requires an estimate of
 - o the proportion of each crime type that is attributable to alcohol consumption: This data is available from NZ Police and Ministry of Transport.
 - o the extent to which crime is reduced as a result of less alcohol consumption.
 - o the cost of crime: The costs to victims were based on the 2006 New Zealand Crime and Safety Survey and the 2007 Business Crime pilot study. From each of these surveys, the average costs to the victims for each crime type were derived and updated to 2010/11 estimates using the Consumer Price Index (CPI). For the cost to government, only the Department of Corrections provides data on both average and marginal costs of crime. This relationship between average and marginal costs was applied to the average costs of crime for the police, courts, DHBs, ACC and New Zealand Fire Service.

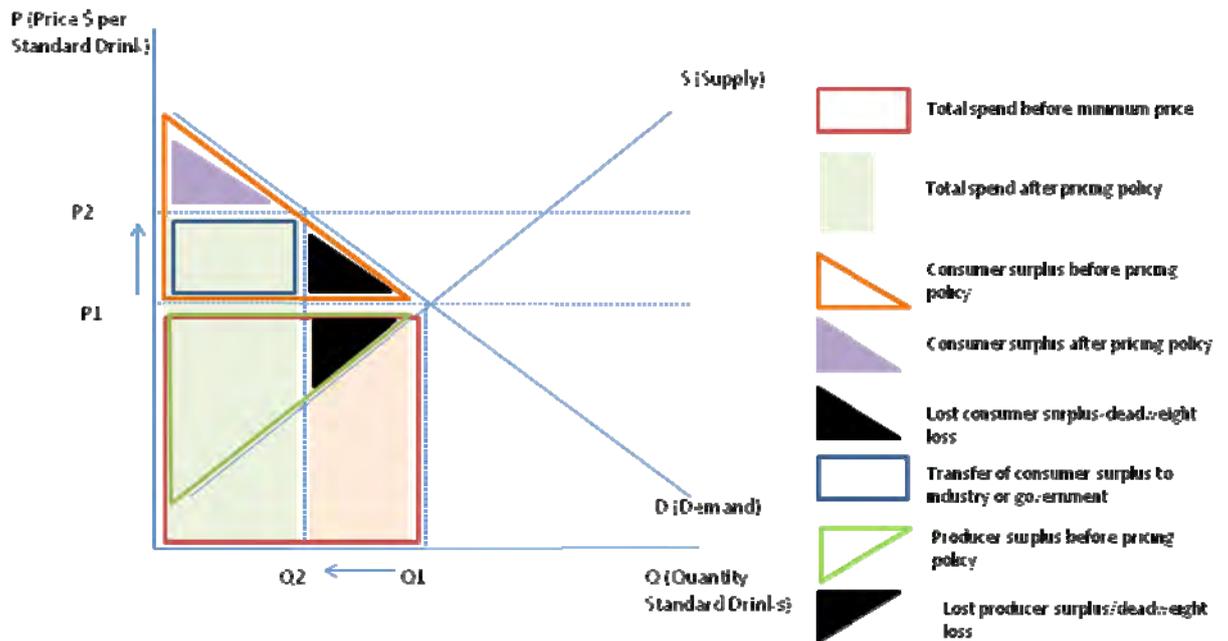
²⁹ A standard drink contains 10g of pure alcohol, and equals approximately 100ml of 12.5% wine or a 330ml can of 4% beer.

- e Work-place productivity gains: The study assumed that the productivity impact on the individual is reflected in the consumer surplus and the slope of the demand curve. Only the impact of productivity gains on the rest of society should therefore be counted. Alcohol consumption is thought to cause three kinds of costs on the rest of society (aside from health and crime costs already accounted for):
 - o frictional costs (the costs saved by businesses in not having to hire workers to replace those who drop out as a result of alcoholism),
 - o the additional PAYE tax as a result of working or working for a higher wage,
 - o the savings in welfare payments (unemployment and sickness benefits).

310. Cost estimates:

- f Consumers' surplus is a measure of consumers' benefit and is the difference between what consumers are willing to pay for an alcohol product and the market price of the product. The willingness to pay for an additional unit declines as the purchased quantity increases. This is illustrated by the demand line in figure 4.

Figure 4: Impact of a price increase whether due to minimum price or increase in excise duty



Source: The study document

As the figure illustrates, an increase in price leads to a decrease in consumers' surplus. Some of this consumers' surplus is transferred to the industry (in the case of a minimum price) or government (in the case of an excise tax increase). This transfer is taken account of in some of the other lines in the cost benefit table.

- i. The size of the loss of consumer surplus can be determined geometrically if the price elasticity of demand is known and the demand 'curve' is assumed to be a straight line. The study surveyed international evidence of price elasticities and researched New Zealand elasticities and consumption levels. The elasticities came out much higher than international estimates. There were methodological issues³⁰, and as a result they were deemed to be unreliable. Estimates produced by a study carried out by the University of Sheffield were typical of other international results and seemed more credible, and were used for the purposes of this CBA.
 - ii. Complications that were considered include the likelihood that different classes of consumers (binge drinkers, heavy drinkers, light drinkers, males and females, different age groups, drinkers of cheap vs expensive beer, wine and spirits, etc) have potentially quite different responses to price changes (ie, different price elasticities of demand), as does on-licence and off-licence consumption. Another issue is that only those who buy drinks below the minimum price will be affected.
 - iii. The University of Sheffield study included separate elasticities for light, moderate and heavy drinkers, and for off- and on-licence consumption. The Sheffield elasticities were combined with the New Zealand consumption data to produce estimates of the reductions in consumer surplus.
- g Transfer to industry: In the case of a minimum price, an increase in price has two effects on the industry, as illustrated in figure x. There is a deadweight loss as a result of reduced production (accounted for in line 3 of the cost benefit table), but there is a gain as a result of the transfer of consumer surplus from consumers to producers (accounted for in line 2). The latter results in an increase in profit for the industry. It is possible that the increased profit is competed away through non-price competition. That is, suppliers will increase the quality of the drinks until the suppliers no longer make super-normal profits. The transfer to industry is, in effect, returned to consumers in the form of increased quality, which increases their consumer surplus. While this point was acknowledged in the analysis, it was not explicitly modelled. However, who exactly ends up with the consumer surplus shouldn't make a significant difference to the overall results. Either way, the social cost of an increase in price is not as great as suggested by the measured reduction in consumer surplus in line 1 of the table – it is ultimately just the black deadweight loss triangles.
- h Industry asset value: Because the quantity demanded and therefore supplied drops, some alcohol industry-specific assets will become idle and will have to be written off. This loss needs to be taken into account in a CBA.

The study assumed that 90% of the reduced demand would be replaced by exports. The remaining 10% of the reduced demand results in a reduction to the value of the industry's capital assets with a ten year remaining life. The devalued asset was discounted over the ten year period.

³⁰ Principally the study's inability to distinguish between regular and promotional prices, which may have inflated the elasticities.

i Because less alcohol is consumed, excise tax revenue falls.

311. Costs and benefits not counted:

a Harms accruing to people other than the drinker should be counted, but have not been due to data limitations.

b The impact of alcohol on volunteering has not been counted due to absence of data.

312. A number of other impacts or costs that have not been estimated are outlined in the study.

313. Quality adjusted life years (QALYs), a measure that incorporates both quality of life and life expectancy, were excluded because they are essentially a private cost is assumed to have already been taken account of in the size of the consumer surplus.

Assessment

314. There are a number of problems and limitations in this study, most of which are acknowledged. Data limitations, in particular, are costly to overcome. The main methodological improvement suggested by this guide would be the use of ranges instead of point estimates: ranges would reveal the extent of uncertainty, including the likelihood that the net social benefit of a minimum price is in fact negative; and explicitly testing the end point of ranges would help reveal the likelihood of bias in the central estimates.

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