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Public Spending Code

A Guide to Economic Appraisal: Carrying Out a Cost Benefit Analysis

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Document Summary

CBA is a key economic appraisal technique under the Public Spending Code. This document provides an introductory guide to CBA. It sets out the aims and principles of CBA and highlights the main technical issues in estimating costs and benefits. It also covers the important issues of CBA performance indicators and risk assessment. It concludes by outlining the presentation and reporting requirements for a completed CBA and provides some references for further reading.

This guide will be updated to reflect the *Public Spending Code A Guide to Evaluating, Planning and Managing Public Investment December 2019*.

Contents

1 Principles of Cost Benefit Analysis

1.1 Introduction

This chapter looks at the theory and principles of CBA including the rationale for its use in the public sector, the importance of defining the project and the counterfactual. It also includes an overview of the issues and limitations of CBA.

Cost Benefit Analysis is concerned with economic choice and endeavours to assist decision makers in making choices concerning scarce resources. In the private sector, the goal of the organisation is purely financial - to maximise profits. In its investment decisions, the organisation is only concerned with private costs and benefits, which are decided by the market mechanism. The organisation will make those choices which contribute most to profit. The difficulty for the public sector is that it must consider the wider implications for society – the social costs and benefits.

> **For the most part the public sector does not operate within the market mechanism for its goods and services and therefore the valuation of social costs and benefits is more difficult.**

1.2 Effectiveness in the Public Sector

In the public sector there is a vast number and diverse range of potential uses of resources and the efficient use of resources has a significant impact on the welfare of citizens. As resources are finite, a decision to implement one proposal may preclude implementing others. There are always alternatives that need comparison even if the choice is between 'doing something' and 'doing nothing or the minimum'. In considering a spending proposal, decision makers need to be assured that the overall welfare of society is raised as a result of the proposed action. CBA attempts to evaluate the proposal from the perspective of society by placing all the costs and benefits on a comparative monetary scale.

1.3 Defining the Project

The importance of defining the scope and objectives of the proposal cannot be overstated. A project subjected to appraisal through CBA must be a clearly identified "self-sufficient unit of analysis"[1]. It is therefore essential to specify the project boundaries before attempting to define the project objectives. Box 1 sets out an illustrative example.

Box 1: Defining the Project

If the project is to upgrade a commuter rail line, the definition of the **project** should clarify exactly what is included and excluded. For example, are rail stations, car parks and access roads to be included or excluded?

Sometimes, a project may consist of separable and independent components e.g. a regeneration project consisting of recreational facilities, residential units and roads. In this case, the separable components should be appraised on their own terms but also in combination. The entire package of components should also be appraised as a project.

Projects should include network effects as part of the project scope e.g. diverted road traffic due to a rail project. A good CBA will contain a definition of the scope of the project and justify this definition.

It is important that the objectives for proposals are specified in terms of a need to be met instead of a particular solution which has been prematurely selected.

1.4 Defining the Benchmark

A CBA study should clearly identify and examine a benchmark or counterfactual for comparative purposes. The counterfactual involves an assumption about the future state of the world in the absence of the project. Comparisons can be made between competing proposals including the status quo. Commonly used counterfactuals include 'do nothing' or 'do the minimum' options. However, it should be noted that counterfactuals based on the do nothing are often unrealistic as there are generally certain costs associated with current arrangements which must be incurred even if a spending proposal does not go ahead e.g. operational, maintenance or repair costs. The do-minimum option is therefore a better

[1] European Commission '*Guidance on the Methodology for carrying out Cost-Benefit Analysis*' - August 2008

benchmark for analysis. It is important that several, realistic options are analysed against the benchmark so that the most effective option can be identified.

1.5 Rationale for CBA

No policy programme or project should be adopted without first having to answer the following questions[2]:

- What are the specific objectives and outcomes sought?
- Are there better ways to achieve these outcomes?
- Are there better uses for these resources?

CBA is a useful evaluation tool which takes a long term and wide view of the consequences of a programme or project and has been developed to help answer these types of questions. CBA is flexible and can be adopted to include all the costs and benefits – private and social, direct and indirect, tangible and intangible. There are some limitations described in Section 2.7 and in particular, it may not be possible to assign a monetary value to all costs and benefits.

1.6 Steps in Carrying Out a CBA

The CBA is one part of the overall appraisal process for a programme, project or scheme. Document B01 sets out the standard appraisal steps for a project or programme. These are:

(i) Define the objective
(ii) Explore options taking account of constraints
(iii) Quantify the costs of viable options and specify sources of funding
(iv) Identify the risks associated with each viable option
(v) Decide on a preferred option
(vi) Make a recommendation to the Sanctioning Authority

This document focuses mainly on steps (iii) to (vii) which comprise the key tasks in a CBA.

[2] NZ Treasury '*Cost-Benefit Analysis Primer*' - December 2005

1.7 When to Carry Out a CBA

A CBA should feature at the business case stage prior to the project approval decision. It is necessary to carry out or update the CBA at other points in the project cycle (at the planning stage when more accurate information will be available on project scope and costs). A revised CBA should be undertaken where project costs increase significantly prior to contract signing. A final reassessment of demand and costs should be undertaken if there is a significant time lag between the appraisal and commissioning of the project.

1.8 Limitations of CBA and Related Issues

The CBA approach is a very useful analytical tool for public sector decision makers which enables the identification of a preferred option and supports resource allocation decisions. It can make assumptions explicit that may otherwise have been overlooked and it also provides an indication of the efficiency of projects. It provides a structured approach for appraisers to consider all the impacts of a project. However, there are limitations associated with the technique.

In the private sector, factors such as profit motive, shareholder wealth and increased market share may all be considered as indicators of effectiveness or benefits from undertaking a particular project. All of these benefits are easily quantifiable and comparable.

> **The public sector must serve the public interest and must consider broader indicators of effectiveness which are less quantifiable.**

In particular, it is difficult to monetise certain intangible benefits (e.g. noise pollution, benefits of scenic attractions etc).

There are also problems around the specification of objectives. Public projects often have broad, complex or unclear objectives or indeed multiple or apparently conflicting objectives. There may also be different perceptions of objectives and difficulty in distinguishing outputs from outcomes and effects or linking outcomes to objectives. The analysis often includes subjective assumptions regarding non-economic variables, made by the appraiser, and the results therefore require careful interpretation.

It should also be borne in mind that CBA is a forecasting technique which necessarily involves predicting the future. This is inherently difficult and there is a risk of a false accuracy attaching to the results of detailed CBA models.

> **Ultimately, the CBA is as good as the underlying assumptions and data.**

Gathering good data takes time and can impose onerous staffing requirements.

Given that CBA is a technical exercise, care and attention is required to ensure that errors such as double counting, incorrect use of parameters and estimation inaccuracies are avoided.

In all cases, CBA should be accompanied by critical judgement and rigorous scrutiny. Qualitative factors should be taken into account along with the CBA in making the decision. Affordability considerations also play a role as projects may have a positive NPV or BCR result but nevertheless may be unaffordable due to funding constraints.

Despite these limitations, CBA is a key component of project appraisal in most OECD countries.

2 Identifying and Valuing Costs and Benefits

2.1 Introduction

While the procedure for conducting a CBA can be set out in relatively succinct steps, there are some difficulties in the application of CBA. This chapter offers a guide to the main practical and technical considerations in conducting a CBA, including identifying and valuing costs and benefits.

2.2 Identifying Costs and Benefits

A common mistake in CBA is failure to identify all the relevant costs and benefits. A comprehensive approach should be taken to insure all relevant costs and benefits are included. The analyst should consider tangible and intangible flows. Some of the costs and benefits may be easily quantified and others are more difficult to quantify. It can be useful to consider the different costs and benefits arising by considering the impacts on different stakeholders affected by the project being appraised.

2.2.1 IDENTIFYING COSTS

The costs of a project should reflect the best alternative uses to which resources can be put or opportunity costs. Opportunity costs should usually be reflected in market prices. It can be useful to categorise the various types of incremental costs which arise in a project. One approach to identifying costs involves the distinction between fixed, variable and semi variable costs:

- Fixed costs remain static over a given level of activity or output e.g. rent
- Variable costs change in line with changes to the volume of activity or output e.g. operating costs
- Semi variable costs can include a fixed and a variable component e.g. maintenance costs

Categorising costs is important because it gives an insight into cost behaviour and the drivers of individual costs. Cost can also be categorised as direct, indirect or attributable overheads. When attributable overheads are included, these should be calculated on an incremental basis only i.e. the change in overhead costs resulting from the project.

> **It is also important that costs are calculated on a marginal instead of an average basis i.e. the costs which apply specifically to the incremental project outputs.**

For example, the marginal cost for road maintenance on a particular stretch of road included in a project proposal may be lower than the average costs applying to an entire route. Capital and operating costs should be included in the analysis. Capital costs will tend to arise in the earlier time periods whereas operating costs arise on an ongoing basis throughout the project. Cost estimates should always ensure that all lifecycle costs are included. Any cost increases arising in later iterations of the CBA should always be reconciled back to the initial values to explain the reasons for cost increases.

Typical costs arising in projects include:

- Staff
- Investment costs e.g. construction costs, materials etc.
- IT costs
- Fixed assets
- Equipment
- Overheads
- Operating costs
- Maintenance costs
- Negative externalities (e.g. water/noise pollution)

Depreciation should not be included as a relevant cost because it is an accounting concept used to allocate expenditure over the life of an asset. The inclusion of the purchase price and depreciation would constitute double counting.

2.2.2 IDENTIFYING BENEFITS

The benefits of a project can be more difficult to identify because these are often not obvious cashflows but are outcomes relating to the objectives of the CBA. In identifying benefits, the analyst should have due regard to the direct and indirect effects of the interventions.

Typical benefits may include among others:

- Reduction in loss of life

- Reduction in health care costs
- Accident savings
- Travel time savings
- Reduced environmental emissions
- Lower operating and maintenance costs
- Job creation
- Increased water quality
- Scenic benefits

2.3 Valuing Costs

Market prices normally reflect the best alternative uses to which the goods or services could be put or the opportunity cost. Cost estimation is a vital task and requires professional input.

A key pitfall to avoid in cost estimation is related to the scope of the project and the related planning/design specifications. The design for a proposal can be a driver of high costs, particularly if the planned capacity is unnecessary given projected demand.

Some additional cost estimation issues are set out below.

2.3.1 SUNK AND OPPORTUNITY COSTS

Sunk costs are costs incurred before the appraisal period and for which there is no opportunity cost. Sunk costs could include expenditure on previous feasibility studies. CBA is only concerned with costs about which decisions can still be made[3].

2.3.2 CONTINGENCY COSTS

Allowance should be made where contingencies are part of the expected costs of the proposal and included in the CBA. Projects with large initial capital outlays should include a contingency provision for escalating construction costs or delays. There may also be specific contingencies arising from contractual obligations which are triggered by certain events occurring. The project analyst should consider whether there is any applicable evidence regarding contingency costs from similar projects in the same sector.

[3] UK Green Book Chapter 5

2.3.3 SHADOW PRICES

The project inputs should be valued at their opportunity cost. It is generally recommended that market prices are used to value the cost of inputs as these best reflect the opportunity cost involved. Market prices are generally reliable and verifiable. However, in some cases market prices do not reflect opportunity costs due to market failures. Shadow prices may then be used although there should be clear and convincing reasons for doing so. Some of the most common shadow prices used are briefly described out in box 2.

Box 2: Typical Shadow Prices Used in CBA

Shadow Prices	Description
Shadow price of public funds	The distortionary impact of taxation
Shadow price of labour	Imperfections in labour market
Shadow price of profit	Including some element of profit as a gain instead of at a 100% opportunity cost
Shadow price of carbon	Calculating the price of emissions

It should always be possible to demonstrate that shadow prices are derived using sound means of calculation. Regard should be had to national guidance on shadow prices contained in the *Public Spending Code Central Technical References and Economic Appraisal Parameters July 2019*. Some detail on the key shadow prices are set out below.

Shadow Price of Labour

The shadow cost of labour has a significant influence on the outcome of a CBA. Labour is one example of an input where a shadow price is sometimes justified due to labour market conditions. It is the opportunity cost to the project of the labour used in delivering the project benefits. Labour conditions can vary on a regional and sectoral basis e.g. unemployment can be higher in certain regions and there are certain economic sectors where demand for labour varies due to the differing levels of skills required. If there are labour resources with zero opportunity costs (i.e. unemployment), the wage rate can overstate the overall social opportunity cost and it can be argued that people who are unemployed and who subsequently

gain work on a project would otherwise not be employed in a productive way. In this case, the wage rate would be replaced with a lower opportunity cost. The shadow price of labour is often expressed in percentage terms. The value of this parameter depends on labour market conditions (e.g. unemployment, regional variations, labour force participation etc), project characteristics and skill levels. A single central value cannot take into account all these factors as these must be taken into account in individual project appraisals.

Shadow Price of Public Funds

Taxation gives rise to economic distortions by altering the incentives facing economic agents, leading to changes in their behaviour and reduced economic activity. For this reason, the shadow price of public funds is greater than one. Put another way, a €1 private benefit resulting from a €1 grant raised by extra taxation does not imply a neutral result for the economy. A premium must be attached to the nominal costs of the proposal in order to make private cash flows commensurate with public cash flows and account for the deadweight loss of taxation. If public costs and private benefits are treated equally, the net present value of projects will be systematically overestimated. In practice, the distortionary costs can be incorporated in cost-benefit analysis by adjusting public benefits and costs by a factor to make them commensurate with private benefits and costs. Economic theory suggests that the distortionary costs of taxation vary roughly in line with the square of the marginal tax rate.

Shadow Price of Carbon

It is necessary to include the impact of environmental emissions. These include various greenhouse gases such as carbon dioxide, nitrous oxide, sulphur hexafluoride, hydroflourocarbons and perflourocarrbons. Project analysts should monetise the value of these emissions into carbon dioxide emissions.

Shadow Price of Profit

This should generally reflect the opportunity cost of the capital in its best alternative use. This will generally involve a shadow price of 100% unless a justification can be made for using a shadow price lower than 100%.

2.4 Valuing Benefits

Benefits should always be valued based on willingness to pay. Where market values are not available (e.g. scenic benefits, value of life, value of time), other techniques can be used. These include stated preference techniques such as contingent valuation as well as revealed preference techniques such as hedonic pricing and travel cost analysis. Ideally, revealed preference techniques should be used because this reflects real behaviour whereas stated preference techniques reflect hypothetical choices in response to questionnaires and surveys. These techniques are summarised in box 3.

Box 3: Valuation Techniques for Benefits

Revealed Preference	Inferring a Price From Observing Consumer Behaviour
Hedonic Pricing	Using the different characteristics of a traded good to establish the value of a non-traded good e.g. value of a seafront by comparing prices of houses with an without the seafront
Travel Cost Analysis	Using the value of traded goods and services to estimate the value of non-traded goods and services e.g. value of an amenity using travel costs and time
Stated Preference	Estimated by asking people what they would be willing to pay for a particular benefit: can be willingness to pay or willingness to accept
Contingent Valuation	Asking consumers about value they would place on outputs/benefits through interviews or questionnaires

The principle of proportionality should always be adopted i.e. if the amount of efforts and resources required to quantify a particular benefit outweighs the advantages of including it, it should not be quantified but a qualitative assessment should be clearly made.

The following sections contain outline material on the key considerations for estimating benefits as well as some typical benefits.

2.4.1 ANALYSIS OF DEMAND

An important driver of the quality of a CBA is the rigor of demand estimates. The projections of demand for a proposal must be based on reliable evidence and subject to independent, expert validation. Data on demand should be based on existing sources and if necessary, efforts should be made to gather new data on demand from primary sources.

Demand analysis should always focus on incremental demand and reflect projected actual demand as opposed to potential demand. It should be noted that the pattern of demand take up may vary over time and that demand may ramp up at a slow or a quick pace over time, depending on a variety of circumstances e.g. state of the economy, employment levels, population growth etc.

The project analyst should carry out a demand analysis which takes into account the role of determinants such as price and non-price determinants such as income levels, expectations etc. Demand forecasting techniques include, among others, extrapolation methods, consultation with experts and econometric analysis.

2.4.2 VALUE OF TIME

Transportation projects frequently involve time savings as a benefit. Time savings generally account for a significant share of the benefits of major transport projects. There are different types of time savings i.e. work time and leisure time. Time saved in the course of work or travelling to work is measured by output which equates to the average wage rate for labour plus overheads and employment taxes.

Leisure time valuation is more difficult to assess but is generally valued at a cheaper rate compared to work time.

The calculation of the value of time benefits often involves the aggregation of time savings across many users as for individual users the time savings may be small.

There are already existing sector specific guidelines regarding the parameter values for the value of time published by the Department of Transport, Tourism and Sport.

2.4.3 VALUE OF LIFE

It is sometimes necessary in CBA to put a monetary value on a human life or more correctly the benefit of saving a human life. This is a difficult but necessary element of CBA but there must be some rational basis to choose between projects or project options that propose to save a human life. Common methods to place a monetary value on a life included foregone earnings (as the lifetime contribution to national output expressed in present values), willingness to pay for additional safety or willingness to accept payment for bearing additional risk for life.

2.4.4 RESIDUAL VALUES

If the project has capital assets that have a useful life exceeding the time period of the CBA, the residual values of the assets should be calculated and included as a benefit. It is important that residual values are accurately estimated and include any offsetting costs such as decommissioning or remediation costs. Residual value should be understood as the market value for the fixed assets (or liquidation value of assets in the case they are sold out at end year) and includes the appraisal of the net revenues the project can generate beyond the time horizon.

2.5 Other Technical Considerations

2.5.1 EXTERNALITIES

All economic activity has both positive and negative effects. An externality is a side effect to an economic action that affects a third party. Externalities can be benefits or costs which affect third parties who are not charged for the benefit or compensated for the cost. External benefits include public good effects and beneficial spillover effects for third parties (e.g. new tourist facilities may benefit local businesses). External costs include congestion effects and pollution. Only those externalities which represent a significant project outcome and which can be valued on the basis of a reliable, well-established methodology should be included in the actual CBA. Examples of externalities for a rail project include noise pollution (negative) and reduced carbon emissions (positive). A CBA model may include externalities in both the cost and benefit sections of the CBA analysis.

It can prove difficult to price externalities. Studies and national guidelines can provide useful reference values. International data may also be available but it is always advisable to critically assess whether such externality values are suitable in an Irish context. In the first instance, due regard should be had to national and sectoral guidelines issued by D/PER and line Departments for key types of externalities.

Significant externalities which cannot be given a monetary value should be excluded from the cost-benefit calculation but nonetheless fully assessed in the cost-benefit report in such a way as to ensure their full consideration in the decision-making process.

2.5.2 DEADWEIGHT, DISPLACEMENT AND ADDITIONALITY

Deadweight occurs when public expenditure is incurred to achieve benefits which have would been achieved in the absence of the project scheme being funded. Deadweight is closely linked to addtionality. Additionality takes place when the funded project achieves benefits which otherwise would not have been achieved and these benefits can be attributed to the intervention. Benefits should be valued net of deadweight and should reflect the best estimate of additionality accruing to a project.

Measures of deadweight can be difficult to source. There may be reference values for deadweight from Irish sector specific models or previously conducted research studies and Value for Money reviews. Commonly used research methods to establish deadweight include, for example, control/comparison group studies, but there are practical barriers to establishing a control group.

The possibility of the project displacing other economic activity should also be specifically examined. For example, it is reasonable to assume that the construction of a Visitors Centre in a particular locality could lead to a reduction in tourism levels in a different area and for the purposes of a CBA, it is necessary to revise the stream of benefits downwards in accordance with the estimated volume of displacement.

2.5.3 TAXES AND SUBSIDIES / TRANSFER PAYMENTS

In general, transfer payments should be excluded because from society's perspective such payments have no effect on real resources and benefits are merely transferred from one part of society to another e.g. unemployment benefits. Such issues are best considered in an Exchequer cashflow analysis (see *Carrying Out A Financial Analysis* on the Public Spending Code website).

However, to the extent that the economic activity arising from the project will be additional (i.e. not displaced), the tax revenues arising, including PRSI, should be included as a benefit. Care should be taken to avoid double-counting in this regard: taxation is a portion of the total value-added (benefit) generated by the project; it is not a benefit in addition to the total value-added generated. Grant-aid and subsidies to the project should be included as a cost. Exchequer cash flows (taxes and grants) should be shown separately from other cash flows.

2.5.4 DOUBLECOUNTING

A common error made in CBA analysis relates to the double counting of the same benefits. This artificially increases the BCR and NPV value. Any type of benefit that is not deemed to be additional should not be included in a CBA. For example, it is reasonable to assume that the construction of a Visitors Centre will have a consequent impact upon house prices in the locality due to the presence of any improved amenity, rise in tourism, etc. However, if this benefit is estimated and captured already in the CBA, it would be double counting to also include the rise in house prices. Other examples of double counting include:

- Including both commercial revenue from usage charges and economic benefits to users e.g. including total toll revenue and total time savings for a transport project
- Value of time savings for a road project and benefits for local shops
- Including the shadow cost of labour in the cost component of the CBA and simultaneously including wage benefits from the same job creation in the benefits component of the CBA
- Including wages as a result of job creation due to an intervention and also including the tax revenue additionality as a separate cashflow.

2.5.5 APPRAISAL TIMEFRAME

The appraisal timeframe should be the economically useful life of the project.

3 Present Values and Discounting

3.1 Basics of Discounting

People generally prefer to receive benefits as early as possible while paying costs as late as possible. Costs and benefits occur at different points in the life of the project so the valuation of costs and benefits must take into account the time at which they occur. This concept of time preference is fundamental to CBA and so it is necessary to calculate the present values of all costs and benefits.

3.2 Selection of Discount Rate

The discount rate is important because if affects the outcome of the NPV. A high discount rate tends to reduce the NPV because the benefits of capital projects tend to materialise in later time periods whereas costs are incurred in earlier time periods. There is a significant body of literature around the calculation of the discount rate and there are several methods to estimate the rate. In Ireland, two methods which have been used to date include the social rate of time preference (SRTP) and the social opportunity cost of capital. The current discount rate calculation is based around the SRTP method. There are other methods of calculating the discount rate e.g. the weighted average method and the social return on private investments.

The Public Spending Code provides that a common discount rate should be used for appraising public expenditure. This is important because it ensures uniformity of approach in calculating present values across the public sector and it also removes the incentive to adjust the discount rate to affect the outcome of the NPV analysis.

The Test Discount Rate (TDR) for use in cost benefit analysis and cost effectiveness analysis of public sector projects is currently 4%. This is the rate in real terms (i.e. excluding projected inflation) and should be applied to a project's future costs and benefits expressed in constant prices (i.e. excluding projected inflation).

There are a number of other issues which will be taken into account in the formulation of a revised test discount rate. These include:

- The potential use of hyperbolic discounting[4]
- The most appropriate estimation method for a revised discount rate
- Calculating the input values for the estimation method chosen

[4] This refers to the use of lower discount rates for longer time periods and is a different approach compared to the more commonly used exponential discounting technique.

For commercial public projects, the cost of capital or a project-specific rate should be used.

Discounting can easily be carried out in Excel. The method for applying the discount rate is set out in box 4 below.

Box 4: Applying the Discount Rate

Discounted value = Future value/cashflow X relevant discount factor

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

n = time period

3.3 Inflation and Interest Rates

The monetary value of costs and benefits should be expressed in real terms so that the effects of inflation do not distort future cost and benefit streams. This is consistent with the use of a constant (real) test discount rate. Interest payments are reflected in the discounting process and so should not be included in the analysis. It may be necessary to deflate future cash flows which reflect expected inflation by using a deflator based on forecast inflation levels.

Real adjustments to prices over time may be made if there will be changes to the price of a good or service relative to all other goods and services. These effects should be reflected in the analysis. Such price effects may occur for the following types of costs:

- Technology products where prices may rise/fall over time for legitimate reasons i.e. some computer technologies will become out of date and become less costly or some technologies (health) naturally tend to cost more over time as additional functionality is added
- Resources which are scarce and where constrained supply will lead to price increases e.g. petrol
- Input costs where market dynamics such as increased competition may lead to reduced prices over time

The expertise on relative price movement should always be sought from appropriate expert bodies and economists with experience in the area. However, unless empirical evidence is available, real prices which assume constant price levels should be used.

4 Analysing the Options

Having identified and quantified the costs and benefits there are a number of methods/performance metrics which can be used to differentiate between options. These include:

- Net Present Value Method
- Benefit Cost Ratio
- Internal Rate of Return

These are also described elsewhere in the Public Spending Code.

4.1 Net Present Value

The NPV is the sum of the discounted cash flows over the period. This criterion is simply based on whether the sum of discounted benefits exceeds the sum of discounted costs. The NPV of several options or projects can be compared in order to rank projects although care should be taken to ensure that NPV comparisons are for proposals with equal lives. In addition, there may be qualitative factors which, when taken into account, affect the selection of the preferred option.

The NPV of proposals can be presented for alternative options or can also be expressed as incremental differences to the do minimum or do nothing.

NPV analysis can be best carried out using spreadsheets which contain standard formulas for calculating present values. Box 5 overleaf contains a sample presentation of an NPV analysis. There are different ways of presenting the NPV analysis. However, the individual costs and benefits should always be clearly identifiable and the final result should be highlighted. The underlying assumptions should also be noted alongside the NPV analysis along with a clear illustration of parameter values.

Box 5: Example of an NPV Calculation (Transport)

Ref	Flows	Year 1 €m	Year 2 €m	Year 3 €m	Year 4 €m	Year 5 €m	Year 6 €m	Year 7 €m	Year 8 €m	Year 9 €m	Year 10 €m	Total €m
	Benefits											
	Travel time saving			038	0.9	1.0	1.1	1.1	1.1	1.1	1.1	8.2
	Accident savings			0.3	0.4	0.5	0.6	0.7	0.7	0.7	0.7	4.6
	Carbon emission savings			0.2	0.2	0.3	0.5	0.7	0.9	1.0	1.5	5.3
(a)	Total economic benefits	0.0	0.0	1.3	1.5	1.8	2.2	2.5	2.7	2.8	3.3	18.1
	Costs											
	Land	-10.0										-10.0
	Buildings	-5.0										-5.0
	Operating Costs		-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-9.0
	Maintenance costs			-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-4.0
(b)	Total economic costs	-15.0	-1.0	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5	-28.0
	Net benefits/costs (b) - (a)	-15.0	-1.0	-0.2	0.0	0.3	0.7	1.0	1.2	1.3	1.8	-9.9
	Discount factor @ 4%	0.9615	0.9246	0.8890	0.8548	0.8219	0.7903	0.7599	0.7307	0.7026	0.6756	
	Present value	-14.4	-0.9	-0.2	0.0	0.3	0.6	0.8	0.9	0.9	1.2	-10.9

Notes

(1) Normally projects have longer durations, 10 years is used here purely for illustrative purposes

(2) The monetary values assigned to costs and benefits are similarly provided purely for illustrative purposes

(3) There are many ways to present an NPV analysis and this example is one variant e.g. cumulative NPV values can be used, years can be used as the row line items, NPV of costs and benefits can be calculated separately etc.

4.2 Benefit Cost Ratio

This is the ratio of discounted benefits to discounted costs. The formula and a worked example is set out in box 6 below.

Box 6: Sample BCR Calculation

BCR = sum of present values of benefits

sum of present values of costs

Example:

Using illustrative data, a sample BCR calculation: = €13.7m = 0.5:1

€25.2m

If the benefit cost ratio is greater than one the project may be accepted as there are more benefits than costs. Unfortunately, however, this method does not take the size of the project into account so the results can be misleading. Generally a BCR of greater than 1:1 is an indicator that the proposal can go ahead as a BCR greater than zero implies a positive NPV but there may well be projects with a greater BCR. As with the other performance indicators, a positive BCR does not automatically mean a proposal is accepted as other issues are relevant such as affordability constraints and qualitative factors.

The BCR is also a useful measure because it allows a large number of projects to be ranked.

4.3 IRR

The internal rate of return is the maximum rate of interest that a project can afford to pay for the resources used which allows the project to cover the initial capital outlay and ongoing ccosts and still break even. It can also be described as the discount rate that equates the present value of benefits and costs. The IRR is generally compared to a hurdle rate of return (normally the test discount rate for public investment appraisal) which corresponds to the opportunity cost of funds.

There are a number of points to note regarding the use of the IRR. There may be mathematically more than one IRR and it can be difficult to know which one to use. There may

also be no one IRR i.e. no discount rate that gives an NPV of 0. It should also be noted that the IRR does not distinguish between projects of different sizes.

4.4 Deciding on a Preferred Option

The rationale for recommending the preferred option should be clear and sufficient evidence presented to decision makers to check the evidence and assumptions leading up to the selection of that option. It may be that the preferred option is not the proposal with the highest NPV due to some critical non-quantifiable or qualitative factors. If this is the case, the specific reasons for disagreeing with the quantitative analysis should be explicitly stated. If there is a budget constraint the proposal which maximises the benefits within the spending constraint should be chosen as the preferred option.

Further detail on presenting and reporting on the results of the CBA analysis is set out in section 6.

5 Risk and Uncertainty

5.1 Assessing Risk and Uncertainty

Project appraisal involves forecasting the values of costs and benefits using the best information available. An inherent problem with the CBA approach is the difficulty in predicting these values. The estimated values of costs and benefits may not materialise as expected due to uncertainty and risk. There may also be biases in the analysis. The risks of adverse conditions and the potential uncertainty associated with each option should be identified and factored in to the decision making process. Realistic assumptions should be made which reduce the element of uncertainty and risk minimisation strategies should be put in place.

It is important that steps are taken to manage risk and uncertainty as part of the appraisal process. The assessment of risk and uncertainty is one the most important components of a CBA and should be given significant attention. There are a number of key steps which should be taken:

1. Ensuring the data and assumptions underlying the estimation of costs and benefits are reliable and realistic
2. Identifying risks e.g. examining each variable to assess the level of uncertainty involved
3. Using risk assessment techniques to assess the level of risk and the impact of risk on project performance including such techniques as:
   a. Sensitivity analysis
   b. Scenario analysis
   c. Expected values
   d. Monte Carlo analysis
4. Devising a risk management strategy including measures to contain, avoid and mitigate risks, as appropriate
5. Communicating the risk management strategy to relevant stakeholders

5.2 Sensitivity Analysis

Sensitivity analysis should always be carried out as part of a CBA. Sensitivity analysis describes the process of establishing the extent to which the outcome of the cost benefit analysis is sensitive to changes in the values of the input variables. It generally involves recalculating the NPV based on changes to the values of variables and assumptions. A comprehensive approach to sensitivity analysis allows the analyst to determine those variables and assumptions to which the NPV is most sensitive. Therefore, it is not sufficient to simply test what are assumed to be the critical variables for the analysis. Instead, the

sensitivity analysis should be carried out for all project variables. In addition, the analyst should test the NPV for significant adjustments to variables (e.g. 10% to 20% +/-) in order to adequately assess the robustness of the CBA.

The results of the sensitivity analysis should also be used during the implementation phase of the project as the project manager should be made aware of the key variables and assumptions which will affect project performance. Particular attention should be devoted to implementing risk avoidance, containment or mitigation measures for these variables and to monitoring out-turn for these variables as the project is implemented.

Care should be taken to avoid a number of pitfalls inherent in sensitivity analysis. For example, if some of the variables are highly aggregated, sensitivity analysis should be carried out on the sub components to ensure that all sensitivities are reflected.

It is important that sensitivity analysis is clearly presented and communicates whether or not a project is worth proceeding even if there are significant changes in the variables.

5.3 Switching Values

A variant of sensitivity analysis involves the use of switching values. The switching value of a variable is that value at which the project's NPV becomes zero or the IRR equals the discount rate. Switching values are generally presented as percentages e.g. the switching value for the investment cost of a rail project is 20% - a 20% increase in the cost would reduce the NPV to zero. Switching values are a good presentational tool in sensitivity analysis because they are easily understood. A useful way to present switching values is to list the values for the key variables in a table.

5.4 Optimism Bias

Optimism bias describes the effect that project analysts overestimate the benefits and underestimate the costs and timings for a project. A range of ex-post reviews of investment projects have shown a systematic tendency to overstate the benefits and understate the costs in the ex-ante appraisal[5]. It is generally accepted that optimism bias can be a common feature of capital appraisal in many countries for both the public and private sectors. Typical examples of optimism bias include forecasts of demand which turn out to exceed actual usage levels for projects or overly ambitious planned schedules for projects which take a much longer time to

[5] Such as Flyvberg (2009) and Florio and Sartori (2010)

deliver. Appraisers should be conscious of this effect and it is critical therefore that optimism bias is avoided.

There are a number of techniques which may be used to address optimism bias. Standard optimism bias factors may be applied to costs and benefits. Best practice requires that sector specific optimism bias factors based on empirical data be used, adjusted where necessary for the specific characteristics of the project under consideration. Project appraisers may also use project specific bias factors where detailed information is available for similar projects previously undertaken. However, neither sector specific nor project specific optimism factors are generally available. Therefore, pending the emergence of detailed optimism bias data for sectors in Ireland, it is recommended that the appraiser take a comprehensive approach to addressing optimism bias by systematically testing low benefit outturns against highest cost outturns for the critical variables as part of the sensitivity analysis. This testing should also include a pessimistic view of the project timings including delays in project delivery.

5.5 Scenario Analysis

Scenario analysis is similar to sensitivity analysis as outlined above. The sensitivity analysis allows users of the CBA methodology to identify those individual parameters and assumptions to which the outcome of the analysis is most sensitive. However, this approach must be augmented to take into account the fact that variables can be inter-dependent in practice.

In contrast to the variable-by-variable approach, the scenario analysis technique recognises that the various factors impacting upon the stream of costs and benefits are inter-independent. In other words, this approach assumes that that altering individual variables whilst holding the remainder constant is unrealistic. Rather, scenario analysis uses a range of scenarios (or variations on the option under examination) where all of the various factors can be reviewed and adjusted within a consistent framework. Scenario analysis takes into account the major political, technological, regulatory and economic uncertainties surrounding a project.

A number of scenarios are formulated – best case, worst case, etc. – and for each scenario identified, a range of potential values is assigned for each cost and benefit variable. The appraiser should compile a series of “what if” questions in relation to the variables to populate the various scenario analyses. When formulating these scenarios, it is important that appropriate consideration is given to the sources of uncertainty about the future (i.e. technical, political, economic etc.). Once the values within each scenario have been reviewed, the NPV of each scenario can then be recalculated. A proportionate approach to scenario analysis should be taken depending on the scale of the project. For larger projects, a more complex approach can be taken.

5.6 Monte Carlo Analysis

Monte Carlo analysis is a risk modelling technique that uses statistical sampling and probability distributions to simulate the effects of uncertain variables on model outcomes. It can be used to model the effects of key variables on the NPV of a given proposal. The approach provides a systematic assessment of the combined effects of multiple sources of risk in key variables and can also allow for known correlations between these variables. The analysis can generate a probability distribution for the NPV. Although it is a useful technique, it requires expertise to apply and interpret the analysis. In particular, critical judgment is required to input the probability distributions of the project variables. If the project analyst is inexperienced in the technique, it is satisfactory to focus on sensitivity and scenario analysis for risk assessment purposes.

6 Presentation and Reporting

The final outcome of the CBA analysis is a recommendation as to whether there is a preferred option and whether the project should proceed or not. Given the importance of appraisal decisions for projects and programmes, it is vital that the results of the CBA are presented and reported clearly, transparently and comprehensively.

Since the readers of appraisal documents are often decision makers who may not have detailed technical knowledge of economic appraisal methods, non-technical language should be used wherever possible to ensure clear communication.

Summary tables should be used to highlight the performance indicator results of the CBA for all the options. There should also be a clear presentation of the main costs and benefits which influence the outcome of the analysis for each option. There should be a summary of the main performance criteria for all realistic options including the NPV values, IRR values (where appropriate) and BCR ratios. It is not sufficient to present unitary values for any of these indicators. Instead, the range of values based on the risk assessment including the detailed sensitivity analysis should be provided. The range of potential outcomes based on the risk assessment should be described. In addition, any relevant decision criteria for the performance indicators should be outlined e.g. the IRR should exceed the official discount rate, the NPV should exceed 0 and the BCR should exceed at least 1:1. Departments and agencies may also have more rigorous decision rules for projects e.g. projects should achieve a BCR of at least 2:1.

The conclusions arising from the CBA analysis should be clearly backed up by and linked to the appraisal analysis contained in the CBA. That said, it is generally not advisable to outline all the detailed assumptions, parameter rules and working rules used to carry out the CBA in this section of the appraisal. These can be provided in detail in the appendices so that the reader can understand the valuation of costs and benefits from first principles. It is however necessary to re-iterate any major issues regarding data sources and assumptions for the CBA e.g. lack of availability of primary data to estimate patronage for a transport project. Similarly if there are major uncertainties regarding parameters or difficulties in monetising certain costs and benefits, these should also be discussed.

The business case document is an important source document for decision makers. Therefore, it should be possible to follow the audit trail of assumptions, data sources, analytical methods and working rules in order to assess the final analysis. However, there are other audiences for the final CBA. It is likely to be subject to internal quality assurance procedures within the line Department or agency. The quality assessment will generally be carried out by someone independent of the appraisal process. The Department of Public Expenditure and Reform may be technically reviewing the CBA for approval purposes. Finally, the CBA may be subject to a post project review or evaluation.

In general, the CBA and related reporting will be contained in a business case document as set out in box 7 below.

Box 7: Contents of the Business Case

In general, the results of the CBA analysis will be contained in a Business Case document containing:

- Rationale for the project, justification and objectives
- Project scope
- Feasibility study including options identification and constraints analysis
- Financial appraisal of all the options
- Economic appraisal of all the options
    - Methodology
        - Assumptions
        - Discount rate
        - Valuation methodologies to estimate costs and benefits
        - Selection of relevant costs and benefits (reasons for inclusion and exclusion)
        - Any significant non-monetary elements identified (including externalities, deadweight and displacement)
        - The justification for the decision criteria used
        - The limitations of the analysis (if any)
    - Options analysis
- Risk analysis
- Planning and design issues
- Evaluation plan and proofing
- Summary and recommendations

The following outlines some guidance to ensure the common problems and pitfalls in presenting the final CBA report:

- Check to make sure costs are not underestimated nor benefits overestimated
- Check that all relevant costs and benefits have been included
- Are the estimation values and parameters robust e.g. shadow prices, WTP values, externalities?
- Is predicted usage based on a sound demand analysis?
- Is there double counting of benefits?

- Is the time horizon appropriate?
- Are there other CBA analyses for the same sector which could be used for reference purposes?
- Are there qualitative factors which should be addressed?
- Does the sensitivity analysis address risk in a comprehensive way?

7 Further Reading and Resources

7.1 Further Reading

There is a wide selection of guides and papers relating to CBA published by academics, Governments and organisations such as the EU Commission. This section provides an illustrative list of CBA material for reference purposes.

Guidance Issued by Departments in Other Jurisdictions

HM Treasury, *'The Green Book', Appraisal and Evaluation in Central Government*, HMSO, 1997.

New Zealand Treasury, *Cost Benefit Analysis Primer*, The Treasury, July 2005

Commonwealth of Australia, *Handbook of Cost Benefit Analysis*, 2006

Guidance Issued by Irish Government and Departments

CSF Evaluation Unit, *Cost-Benefit Analysis in the Community Support Framework: A Critical Review*, June, 1997.

Department of Public Expenditure and Reform, *The Public Spending Code A Guide to Evaluating, Planning and Managing Public Investment*, October 2019

Department of Transport, *Guidelines on a Common Appraisal Framework for Transport Projects and Programmes,* March 2016

Transport Infrastructure Ireland, *Project Appraisal Guidelines*, 2016

Guidance Issued by Other International Organisations

European Commission, *Regional Policy, Guide to Cost -Benefit Analysis of Investment Projects*, July 2008 Edition.

Publications by Academics and Institutes

IPA edited by Michael Mulreany, *Cost Benefit Analysis Readings* (2002).

Brealey, R. A. and Myers, S. C., *Principles of Corporate Finance*, Ninth Edition.

Flyvbjerg, B., Holm,M.,Skamris, K. and Buhl, S.L., *"How common and How large are Cost Overruns in Transport Infrastructure Projects", Transport Reviews, Vol 23 (1):* 71-88 (2003)

Goodbody Economic Consultants in association with Atkins, *Cost Benefit Parameters and Application Rules for Transport Project Appraisal*, 2004

Gray, A. W., *EU Structural Funds and Other Public Sector Investments - A Guide to Evaluation Methods*, 1995.

Honohan, P., *Methodological Issues in Evaluation of Irish Industrial Policy*, ESRI Working Paper 69, January, 1996.

Honohan, P., (ed.), *EU Structural Funds in Ireland: A Mid-Term Evaluation of the CSF 1994-99,* Policy Research Series, No. 31, Dublin: The Economic and Social Research Institute, 1997.

Honohan P., *Key Issues of Cost-benefit Methodology for Irish Industrial Policy*, ESRI General Research Series No. 172, November, 1998.

Morgenroth, E., *How can we improve evaluation methods for public infrastructure*, ESRI, November 2011

Murphy, A, Walsh, B, Barry, F, *The economic appraisal system for projects seeking support from the industrial development agencies*, Forfás 2003

7.2 Other Resources

In addition to the source material outlined above, there are other useful resources which may provide background reading material for CBA analysts. These are summarised in box 8 below. Care is required to ensure that any reference values sourced from international sources are applicable to the Irish context.

Box 8: Additional Resources for CBA

Resource	Description
EVRI Database	Empirical studies on the economic value of environmental and human health effects
Jaspers	Joint Assistance to Support Projects in European Regions. Assists the 12 Central and Easter EU Member States in the preparation of major projects to be submitted for grant financing under the Structural Cohesion Funds
Heatco	Improved decision-aid methods and tools to support evaluation of investment for transport and energy networks in Europe
Eva Tren	Harmonised Approaches for Transport Costing and Project Assessment
Railpag	Railway Project Appraisal Guidelines