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TII Publications

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Project Appraisal Guidelines Unit 6.1 – Guidance on Conducting CBA

PE-PAG-02020
December 2023

PE Planning & Evaluation

Technical

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Transport Infrastructure Ireland (TII) is responsible for managing and improving the country's national road and light rail networks.

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TII Publications

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Updates to TII Publications resulting in changes to

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Amendment Details:

- Reference to Transport Appraisal Framework (TAF) instead of Common Appraisal Framework (CAF)
- Update requirement for CBA for all projects and programmes with estimated lifetime costs equal to or greater than of €30 million, instead of in excess of €20 million
- Guidance on the use of monitised emissions from the TII Road Emissions Model in CBA

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1. Introduction

1.1 Overview

Cost Benefit Analysis (CBA) forms one element of the appraisal process for infrastructure projects. CBA serves a number of functions at both the individual scheme level and when comparing different projects:

- At the individual scheme level, the results of the CBA indicate whether a scheme is economically viable; i.e. whether economic benefits resulting from the provision of the scheme outweigh the costs to construct and maintain it
- They can provide a comparison of alternative options
- At the national level, the Government has finite resources to commit to infrastructure improvements. The outputs from economic assessments allow different schemes to be compared and enable the schemes that provide best value to be identified. If the results of the CBA are to be used to prioritise schemes, then the assessments need to be carried out in a consistent manner

Cost Benefit Analysis is required for all transport projects and programmes with estimated lifetime costs equal to or greater than €30 million[1]. This requirement is stipulated by the Department of Public Expenditure, NDP Delivery and Reform (DPENDR) and the Department of Transport (DoT) under the Transport Appraisal Framework (TAF) for Capital Investment in Transport, June 2023.

Elements of the CBA may be used to satisfy the requirement within the appraisal process to undertake an exchequer analysis as part of Financial Appraisal, which details costs and benefits that will have an effect on Exchequer cash flows including capital and operating costs, taxes, subsidies and revenues in the form of user charges (where these accrue to the public sector). Further details on this Financial Appraisal are provided in PAG Unit 11.0 – Financial Appraisal.

The process of undertaking CBA involves the following key stages, as mandated by DoT and DPENDR:

i) Quantifying the costs and benefits of options being considered and specification of the sources of funding
ii) Analysing these options
iii) Identifying the risks associated with the viable options
iv) Identifying a preferred option
v) Making a recommendation to the Sanctioning Authority

Guidance on the theory and practice of CBA specifically for TII projects are provided within this Unit and in TAF Module 7.

[1] https://www.gov.ie/pdf/?file=https://assets.gov.ie/260306/66dec974-288e-4c60-bc2e-826f16bf04e8.pdf#page=null

2. Cost Benefit Analysis: Principles and Economic Theory

2.1 Why use Cost Benefit Analysis?

Resources, particularly public sector investment resources, are scarce. All Governments are therefore concerned with securing value for money from investment expenditure and with finding tools that measure value for money objectively in areas of public sector expenditure.

Governments need to be able to understand the value for money of different expenditure programmes (e.g. comparing road schemes with investment in other transport projects), to identify priorities within a single programme (e.g. comparing different road schemes) and to understand if individual projects provide value for money.

2.2 Consumer Surplus

CBA was developed for sectors that do not have a marketable output. For this reason, the change in 'consumer surplus' is used as an indicator of wellbeing to measure the benefits of a particular road scheme.

Consumer surplus is the difference between the price consumers are willing to pay for a good or service and the actual market price. If a consumer is willing to pay more than the actual price then the consumer surplus is defined as the difference in the two prices. Where as a result of an investment the cost of a good to the consumer falls, then the Consumers' Surplus will rise. On a standard demand and supply curve, as illustrated in Figure 6.1.1, consumer surplus is shown by the shaded area.

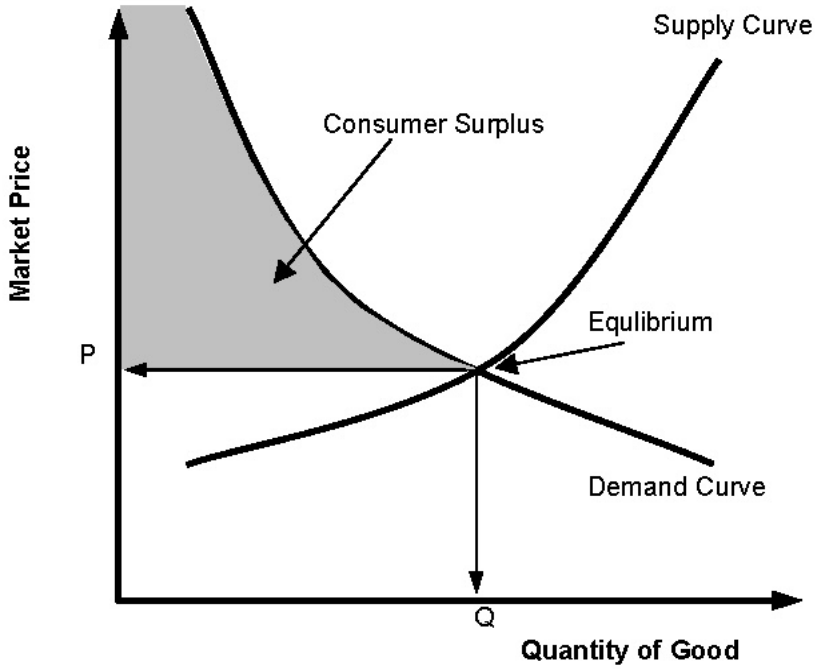

Figure 6.1.1 Definition of Consumer Surplus

The cost that a user is prepared to pay comprises of several elements, including physical payments made (such as fares, tolls and vehicle running costs) and the value that the consumer places on his/her time. These elements are combined into an overall "generalised cost" of travel. Changes in generalised travel costs resulting from a transport scheme give rise to changes in consumer surplus, with positive movements representing a benefit to the consumer.

For example, if an individual is willing to travel for up to 15 minutes to enjoy a particular activity and a transport scheme reduces this time to 10 minutes then the traveller enjoys a consumer surplus equivalent to the generalised cost of five minutes of travel time.

Across all travellers making the same journey, the change in consumer surplus is the difference between the change in the total benefit enjoyed and the change in the costs.

If travel demand remains unchanged (i.e. demand is perfectly inelastic, meaning totally unresponsive to changes in price), but travel costs change, the change in consumer surplus is represented by the shaded area in Figure 6.1.2, and defined by the following formula:

$$\boldsymbol{Change\ in\ Consumer\ Surplus} = (P^0 - P^1)^* T$$

Where P^0 and P^1 are the Do-Minimum and Do-Something travel costs respectively and T represents the number of travellers.

This situation is analogous to the fixed trip matrix assumption, where there is no increase in trips as a result of building a scheme.

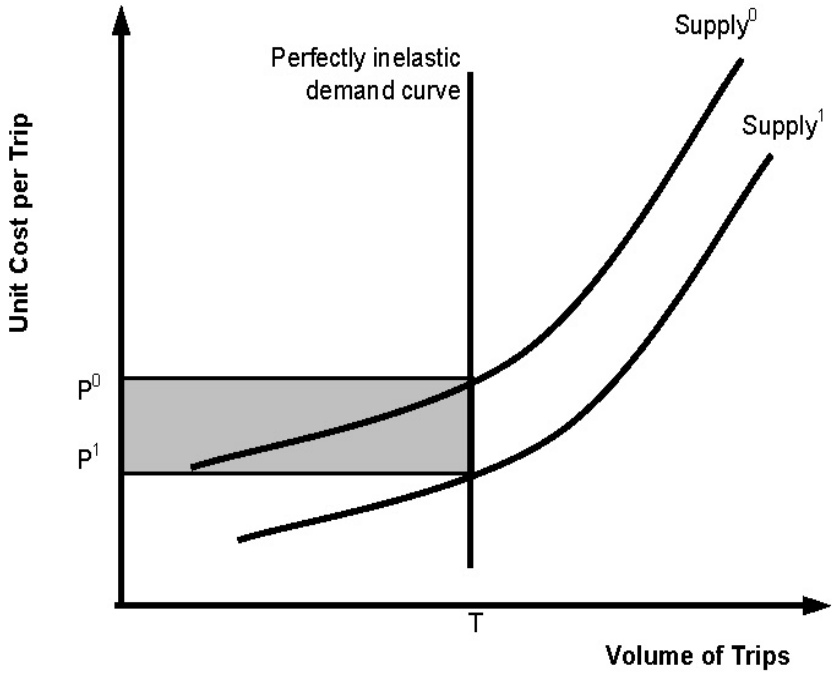

Figure 6.1.2 Change in Consumer Surplus – Fixed Demand

In the case where demand changes as result of changes in travel costs (i.e. demand is not perfectly inelastic), then the change in consumer surplus is as shown in Figure 6.1.3 and defined by:

$$\boldsymbol{Change\ on\ Consumer\ Surplus} = (P^0 - P^1)T^0 + {}^1\!/_2\,(P^0 - P^1)(T^1 - T^0)$$
$$= {}^1\!/_2\,(T^0 + T^1)(P^0 - P^1)$$

This situation is analogous to the variable trip matrix assumption, where there is a change in the number of trips as a result of building a scheme.

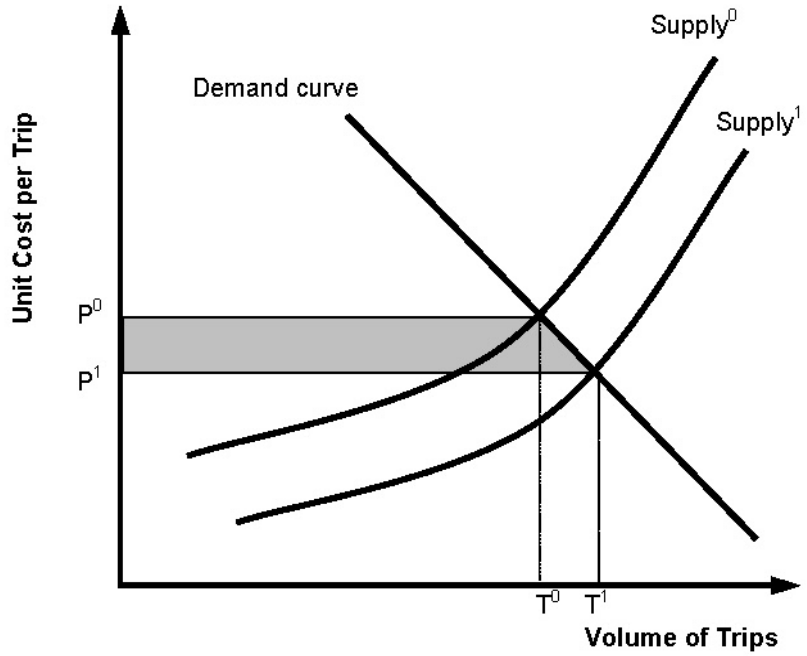

Figure 6.1.3 Change in Consumer Surplus – Variable Demand

The convention in this case is to attribute half of the change in costs (e.g. travel time, vehicle operating costs, tolls and environmental costs) to the change in trips and is known as the 'rule of half'.

2.3 Price Base Year

Implementing a transport scheme usually results in a stream of costs followed by a stream of benefits, some of which have monetary values applied to them. These monetised costs and benefits occur over a number of years and cannot simply be added together as if they all occurred simultaneously.

In order to be able to add costs and benefits that occur over a period of time, two distinct issues must be dealt with:

- General changes in price levels over time (inflation)
- Preferences for consumption now rather than later (time preferences)

The effects of inflation are resolved by means of converting all costs and benefits to a common price base year (using a "price index").

A **2016 price base year** is required in line with the Department of Transport's (DoT) Transport Appraisal Framework (TAF), 2023.

The effects of 'time preferences' can be accounted for by discounting all costs and benefits to a present value.

2.4 Present Value Year

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.

Costs and benefits that arise in different years will have different values. For example, consumers will express a preference for €1 that is received today over €1 received next week or next year. This preference is independent of inflation effects. Costs and benefits arising in different years are therefore expressed in terms of their value from the standpoint of a given year.

To take into account these time preferences, a discount rate is applied, discounting future costs/benefits back to a given year 'the present value year', which is either the first year in which costs are incurred or the current year. Summing the Present Values of Costs and subtracting these from the Present Value of Benefits gives the 'Net Present Value' (NPV) of the scheme at the present value year.

2.5 The Discount Rate

Costs and benefits arising in different years are transformed to their present values by the process of discounting. This can be understood by considering the principle of compound interest. If €1 is invested at a real interest rate of r, at the end of one year it would be worth €(1 + r) and after two years €$(1 + r)^2$ and so on. By the same logic, €1 received in n years' time is worth €$1/(1 + r)^n$ now.

Note that this illustration ignores the effect of inflation and therefore assumes that €1 has the same real spending value in each year. Inflation describes the change in spending power of money across different years and is distinctly separate from discounting. The illustration presented here is based on an inflation rate of zero.

The discount rate that should be employed in all TII project appraisals is to be taken from PAG Unit 6.11 - National Parameters Values Sheet.

Because discounting involves the notion of charging interest against a project, rather than paying interest to an investor, r is known as the discount rate. Any sum may be reduced to its Present Value (PV) by means of the following formula:

$$\boldsymbol{PV} = \frac{S}{(1+r)^{y-p}}$$

Where PV is the present value, S is the sum to be discounted, r is the discount rate, expressed as a decimal, y is the year in which the sum is received or incurred and p is the present value year.

2.6 Net Present Value

The Present Value of Benefits (PVB) represents the value in the present value year of all the benefits that will accrue over the appraisal period. It is calculated according to the following formula:

$$\boldsymbol{PVB} = \sum_{y=year0}^{y=yearn} \frac{B_y}{(1+r)^{y-p}}$$

Where B_y is the benefit occurring in each year, from the first year in which benefits are accrued (*Year 0*) discounted as appropriate, up to the limit of the appraisal period (*year n*).

The Present Value of the stream of Costs (PVC) represents the value in the present value year of all the costs that will accrue over the appraisal period, comprising mainly construction and maintenance costs. It is calculated in a similar way to the approach for calculation of PVB. For some schemes, it is possible that construction costs may have been incurred prior to the present value year. In such cases, this would require an inflation of the scheme costs to the present value year using the discount rate.

The approach to calculating PVC is therefore:

$$\boldsymbol{PVC} = \sum_{y=year0}^{y=yearn} \frac{C_y}{(1+r)^{y-p}}$$

Where C_y is the cost incurred in year y, discounted as appropriate, up to the limit of the appraisal period year n. Year 0 is the first year that costs are incurred, which may be prior to the present value year.

The NPV is the discounted sum of all future benefits less the discounted sum of all future costs over the appraisal period.

The NPV of the scheme can be calculated according to the following formula:

$$\boldsymbol{NPV} = PVB - PVC$$

2.7 Benefit to Cost Ratio

The BCR is given by the ratio of the discounted sum of all future benefits to the discounted sum of all costs. It is one of a number of indicators that describe the efficiency of an investment and provides a means to compare alternative investments. Thus:

$$\boldsymbol{BCR} = PVB \;/\; PVC$$

2.8 Internal Rate of Return

The IRR is the rate of discount that makes the present value of the benefits exactly equal to the present value of the costs. Put another way, the IRR is the rate of discount that makes the NPV of the entire stream of benefits and costs exactly equal to zero and describes the rate of economic return that a defined investment is expected to generate.

The IRR 'λ' is that for which the sum:

$$\sum_{y=0}^{y=n} \frac{B_y}{(1+\lambda)^{y-p}} = 0$$

Where B_y is the net benefit (undiscounted) in year *y*.

It should be noted that there may also be other significant costs and benefits, some of which cannot be presented in monetised form. NPV and BCR are fairly powerful indicators of worth but it should be pointed out that they do not provide information on benefits and costs that cannot be presented in monetised form – refer to PAG Unit 7.0 – Multi-Criteria Analysis, which provides guidance on multi criteria analysis. In other words, although an important input, the economic analysis should not be used as the sole basis for decisions.

2.9 Valuation Principles

In presenting the results of CBA two distinct issues arise:

- Are the results to be presented exclusive of VAT and indirect taxation (i.e. expressed as factor / resource costs) or inclusive of VAT and indirect taxation (i.e. at market prices)?
- Do we present aggregated cost and benefits to society as a whole (social cost calculus) or do we disaggregate costs / benefits according to who bears them (the Willingness-To-Pay calculus)?

It is important to note that the choice of unit of account (i.e. factor versus market prices) or calculus (social cost versus Willingness-To-Pay) is immaterial to the results. It is important, however, to present all results on a consistent basis and to state which unit of account and calculus is used. Current guidance is to present all results in Willingness-To-Pay (WTP) as **Market Prices**. The standard CBA appraisal software (TUBA) already outputs the required summary tables in WTP in market prices.

3. Application of CBA to TII Projects

3.1 Overview

During the overall project timescale CBA will normally be required during the following four phases:

- Phase 2 Options Selection
- Phase 3 Design and Environmental Evaluation
- Phase 5 Enabling and Procurement
- Phase 7 Closeout and Review (a CBA is only required in certain circumstances at this stage)

PAG Unit 2.0 - Project Appraisal Deliverables provides guidance on the Project Appraisal Deliverables required at each phase.

3.2 Phase 2 - Option Selection CBA

At this phase, Option Comparison Cost (OCE) estimates, to be agreed with the TII Cost Estimation Unit, will be used. The CBA must reflect the relative benefits of competing options. Default parameters for traffic composition and collision rates are therefore generally applicable. The Phase 2 CBA only needs to be undertaken for the TII central growth scenario.

3.3 Phase 3 - Design and Environmental Evaluation CBA

The CBA at this phase is more detailed, using local parameter values for traffic composition and, perhaps, local collision rates (where applicable). Target Cost and Total Scheme Budget cost estimates will also be available.

At this stage the CBA must be run (at least) six times, one for each combination of traffic growth scenario ('high', 'central' and 'low') and cost estimate (Total Scheme Budget and Target Cost). For schemes involving tolling, separate tolled and un-tolled scenarios should also be presented.

3.4 Phase 5 - Enabling and Procurement

A Phase 5 CBA should be undertaken to reflect any changes that may have occurred since the Phase 3 CBA was undertaken, this may include any design changes or amendments made to the scheme following planning approval as Phase 4. In addition the Phase 4 CBA should reflect the known tender costs for the construction of the scheme.

3.5 Phase 7 - Closeout and Review

CBAs are only required at Phase 7 - Closeout and Review in certain circumstances, e.g. where impacts are complex and require detailed analysis to fully evaluate. The purpose of the Phase 7 CBA is to determine how the outturn costs and actual post-opening impacts (e.g. traffic volumes, collisions, emissions) compare with forecasts, and how these affect the overall economics of the scheme.

Analysis of a final account CBA can help identify issues relating to the assessment and provide useful information to feed into future assessments in terms of lessons learnt. The final account / closeout CBA should use outturn scheme costs and observed impacts where possible.

The Phase 7 CBA should use, insofar as possible, the same appraisal parameters used in the Phase 3 and Phase 5 CBAs to provide consistency. Analysis of 'high', 'central' and 'low' traffic growth scenarios should be prepared, in addition to any further sensitivity testing deemed necessary.

4. Costs and Benefits

4.1 Overview

All costs and benefits included in transport CBAs should be valued using the standard appraisal parameters set out in PAG Unit 6.11 - National Parameter Values Sheet, which are aligned with TAF. Any CBA modelling that uses non-standard parameters should by default be included only as a sensitivity test within the appraisal process, unless otherwise agreed with TII. Table 6.1.1 sets out those impacts of a project scheme that are monetised and non-monetised. Monetised costs and benefits are described in more detail in Sections 5 to 10 of this document. Non-monetised impacts are to be assessed qualitatively according to the guidance provided in PAG Unit 7.1 – Multi-Criteria Analysis.

Table 6.1.1 Monetised & Non-Monetised Impacts in the Appraisal of TII Projects (TAF Requirements)

TAF Criterion	Monetised	Non-Monetised
Transport User Benefits and Other Economic Impacts	• Travel Time • Vehicle Operating Costs • Tolls • Changes in Scheme Costs and Maintenance Expenditure • Active Travel / Health Benefits • Other Economic Impacts, including Journey Quality, Journey Reliability and Wider Impacts*[2]	
Accessibility		• Access to Services • Access to Recreational Facilities • Access to Jobs • Freight Access
Social		• Impacts on Deprived Groups • Impacts on users with different mobility needs • Gender Impacts
Land Use		• Public Realm • Existing Transport network and service impacts • Zoned lands
Safety	• Changes in Collision Costs	
Climate Change	• Changes in Green House Gas Emissions	
Local Environmental Impacts[3]	• Changes in Air Quality	• Noise and Vibration • Biodiversity • Water Resources and Soil landscape • Visual Quality

[2] Only to be included in CBA under specific circumstances
[3] Additional Local Environmental Impacts are required to be considered and assessed as per the TII Project Management Guidelines

Figure 6.1.4 illustrates how the costs and benefits of a scheme are brought together in the overall appraisal of monetised benefits.

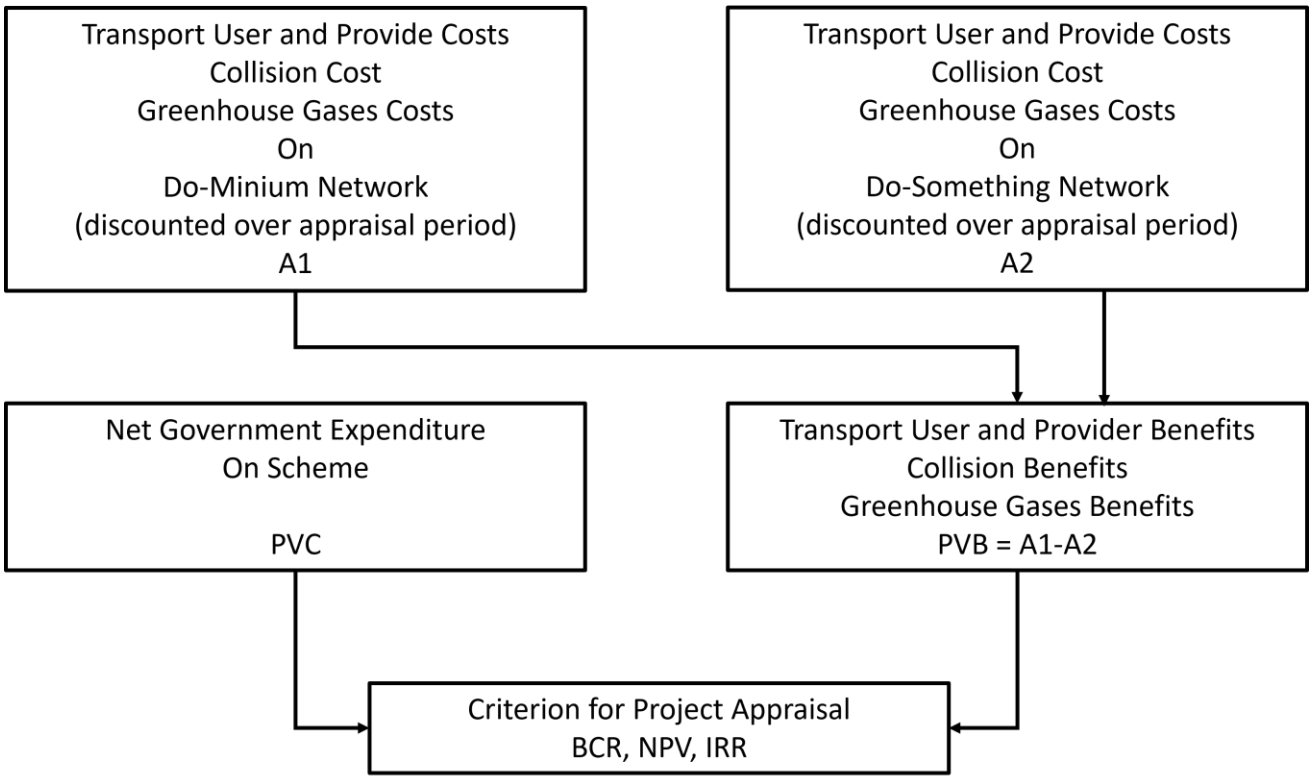

Figure 6.1.4 Overview of the CBA Appraisal Process

5. Values of Time

5.1 Overview

Travel time savings are the major items of the calculated benefit resulting from a typical transport project.

For most schemes the aggregate time saving is positive, with the change in travel time directly or indirectly associated with the proposal, for example:

- Direct changes in travel time are incurred by transport users using the new facility, such as a bypass, rather than the next best alternative
- Indirect changes result from changes in travel times along other routes that may be affected by the scheme

Three distinct purposes of travel are distinguished: travel in the course of work, commuting (travel to and from normal place of work) and other (travel for other non-work purposes). A different value of time can be applicable depending on the journey purpose, vehicle mode and whether the occupant is the driver or passenger.

The latest values of time recommended by TII for use in CBA of road and active travel infrastructure projects are provided in PAG Unit 6.11 - National Parameter Values Sheet. These are in line with parameters provided by the DoT Transport Appraisal Framework (2023).

6. Vehicle Operating Costs (VOC)

6.1 Overview

The use of the road system for example by private cars and Heavy Goods Vehicles (HGVs) gives rise to operating costs for the user. These costs are split into two groups: fuel costs and non-fuel costs, the latter comprising items such as fuel, oil and tyres, and an element of vehicle maintenance.

Road schemes can give rise to changes in operating costs. The change in total Vehicle Operating Costs (VOC) over all links depends on changes in the distance travelled by vehicles and on average link speeds. Whilst for most schemes the aggregate time saving is positive the change in overall VOC can be either negative or positive depending on the balance of changes in distance travelled and speeds.

The current VOC parameter values recommended by TII for use in CBA of road infrastructure projects are provided in PAG Unit 6.11 - National Parameter Values Sheet.

7. Tolls & Fares

7.1 Overview

Any additional charges resulting from tolls of fares should be treated as a cost (disbenefits) to travellers and a reduction in charges should be treated as a benefit.

Toll revenues are a benefit to the toll provider and possibly the Government / TII if they receive a share of the toll revenue. Fares are a benefit to a private service operator or state agency.

In the case of a scheme that proposes a toll, a benchmark CBA should be undertaken for the 'non-tolled' scenario. In such cases, the construction costs should be based on the anticipated tender cost, excluding VAT. Where required by TII, a separate assessment should be undertaken for the tolled scenario. The methodology and the public sector costs required for this evaluation should be agreed with TII.

A common error made when undertaking a CBA relates to the double counting of the same benefits. An examples of toll related double counting which should be avoided is provided below:

- 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 unless toll revenue is taken as a disbenefit to users also.

Further advice on CBA of schemes involving tolling is provided in Section 11 of this PAG Unit.

8. Scheme Costs

8.1 Overview

The total costs of the scheme are considered in terms of:

- Investment costs (including construction, land, labour, preparation and supervision costs)
- Operating costs, relating to changes in the cost of maintaining the network

Detailed advice on how to undertake the computation of scheme costs for input into CBA is provided in PAG Unit 6.2 - Preparation of Scheme Costs.

In the majority of cases, scheme costs will be borne entirely by national Government. However, in some instances contributions may be sought from private developers.

8.2 Exchequer Cash Flow Analysis

The overall net costs incurred by Government will take into account:

- Contributions from developers
- Revenue raised by indirect taxation (as a result of changes in vehicle operating costs), contributions from developers
- Income received from tolled roads. As outlined above, care should be taken to avoid double counting of toll related benefits and revenues

The exchequer cash flow analysis takes these factors into account and information required to complete this analysis, for reporting within the Multi-Criteria Analysis, is taken from standard output files produced by the COBALT, TUBA and REM programs.

8.3 Shadow Prices

The shadow price factor that should be adopted for the Shadow Price of Public Funds and Shadow Price of Labour in all TII project appraisals is to be taken from Pag Unit 6.11 - National Parameters Values Sheet. These are in line with parameters set out in the DoT's TAF (2023).

8.4 Costs During Construction and Maintenance

Delays to users that occur during construction and changes in delays due to routine maintenance are generally only considered for more complex schemes, or when they are likely to represent a significant element of the costs or benefits. In such instances the TII Strategic & Transport Planning team should be contacted to agree a method for assessing such implications.

9. Collisions

9.1 Overview

For road collisions, standard methodologies exist for calculating the projected number of collisions, the types of collisions and associated casualties in the Do-Minimum and Do-Something scenarios. The methods relate the traffic on a road (measured by vehicle-kilometres) to the number of collisions via the application of a collision rate.

Collision rates (and casualty rates) for different road types are set out in PAG Unit 6.11 - National Parameter Values Sheet and these should be adopted. The appraisal process using COBALT will adjust these rates to account for the phenomenon of under-reporting.

Collision rates and collision severity rates are predicted to change over time irrespective of whether or not a specific intervention is being considered. Reduction factors for both collisions and casualty rates are provided in PAG Unit 6.11 - National Parameter Values Sheet.

Standard cost values are attributed to fatal, serious and slight casualties allowing the monetisation of collisions in the before and after scenarios, and hence the calculation of the benefits or otherwise of a proposal.

The standard costs per collision, are given in PAG Unit 6.11 - National Parameter Values Sheet, which also provides costs per collision for insurance administration, damage to property and Gardaí costs for different types of collisions on different types of roads. These are in line with parameters set out in the DoT's TAF (2023).

Local collision data can be used in place of national values for selected links at Phase 3 onwards where such data are considered to be reliable.

10. Emissions

10.1 Overview

Emissions should be considered in terms of the change in the equivalent tonnes of gas released as a result of implementing a scheme. Emissions are estimated from fuel consumption in the Do-Minimum and the Do-Something options. Changes in emissions for the opening year and over the whole appraisal period, should be recorded in the MCA, quantified both in terms of kg of each emission type, and as a monetary value.

The results of the calculation of emissions during construction should also be set out as part of the appraisal process.

10.2 TII Road Emissions Model – CBA Emissions

In December 2022, TII published their Road Emissions Model (REM)[4] which can be used to assess the change in emissions associated with a proposed intervention. The TII REM can also monetise these emissions changes in line with the same economic parameters which underpin TUBA. It is therefore recommended that the TII REM is used to monetise emissions impacts for use in the CBA of TII projects instead of using the outputs generated by TUBA.

The TII REM is based on traffic volumes and average speeds on individual transport model links as opposed to traffic volumes and average speeds between transport model zones (as used in TUBA). This allows for more accurate emissions impacts to be taking into consideration. In addition to the calculation of Carbon Dioxide equivalent (CO2e) as per TUBA, the TII REM also monetises air quality emissions such as Oxides of Nitrogen (NO_x) and Particulate Matter ($PM_{2.5}$), which TUBA does not currently calculate.

10.3 Using the TII REM for CBA Inputs

Figure 6.1.5 shows the Analysis of Monetised Costs and Benefits section of a TUBA output file with the monetised Greenhouse Gases highlighted in red. When using the monetised emissions impacts from the TII REM in CBA, this element of the TUBA output file should be ignored and the value replaced with that generated by the TII REM as per the example output file from the TII REM in Figure 6.1.6.

[4] GE-ENV-01107 (tiipublications.ie)

Analysis of Monetised Costs and Benefits	
Greenhouse Gases	-108
Economic Efficiency: Consumer Users (Commuting)	17177
Economic Efficiency: Consumer Users (Other)	24969
Economic Efficiency: Business Users and Providers	42928
Wider Public Finances (Indirect Taxation Revenues)	1318
Present Value of Benefits (PVB)	86284
Broad Transport Budget	183157
Present Value of Costs (PVC)	183157
OVERALL IMPACTS	
Net Present Value (NPV)	-96873
Benefit to Cost Ratio (BCR)	0.471

Figure 6.1.5 TUBA Greenhouse Gases - Analysis of Monetised Costs and Benefits

Cost Benefit Analysis Summary

30-year Timeframe Change (2025 - 2054)

Pollutant	Change in Emissions (tonnes)	% Change	Monetary Change (€)
CO_2e	+44,750	+7.6	-€2,142,122
NO_X	+720	+19.2	-€1,645,338
$PM_{2.5}$	+45	+8.5	-€263,712

60-year Timeframe Change (2025 - 2084)

Pollutant	Change in Emissions (tonnes)	% Change	Monetary Change (€)
CO_2e	+74,750	+6.1	-€3,014,175
NO_X	+870	+13.2	-€1,739,125
$PM_{2.5}$	+75	+7.2	-€318,009

Figure 6.1.6 TII REM CBA Summary Tables (30 year and 60 year appraisal)

As shown in Figure 6.1.6 the TII REM provides outputs for each individual emission over both a 30 year standard appraisal period and 60 year appraisal period for the calculation of residual impacts. The overall combined monetised emissions value (Climate & Air Quality emissions) from the TII REM should be used in the Transport Economic Efficiency (TEE) Table in the CBA report and relevant Business Case document.

Climate and Air Quality emissions, both the change in tonnes and monetary change can be presented separately as part of the MCA process when appraising Climate Impacts and Local Environment Impacts respectively in line with the DoT TAF criteria.

11. Active Travel

11.1 Overview

A requirement of the appraisal process is the assessment of the desirability of an investment proposal from the perspective of society. Rather than just looking at the financial costs of new active travel infrastructure, an active mode appraisal should attempt to capture the wider benefits provided by active travel infrastructure – such as health benefits, reduction in carbon emissions, or improved connectivity – to assess whether the project would be a worthwhile and prudent investment. There are different methods of appraisal: some types of benefits can be quantified and expressed in monetary terms, which is often referred to as 'Quantitative' appraisal; others can only be described with statements or simple scoring systems, which is referred to as 'Qualitative' appraisal.

PAG Unit 13 – Appraisal of Active Modes should be used for the appraisal of active travel investments. The aim of PAG Unit 13 is to provide guidelines for the appraisal of active mode interventions within the overall project lifecycle, and to ensure that appraisers have the resources and tools to do so for both qualitative and quantitative appraisal. PAG Unit 13 and its supporting TEAM (**T**ool for **E**conomic appraisal of **A**ctive **M**odes) tool will prove useful to a wider range of stakeholders and contexts, including the appraisal of active travel schemes by local authorities, the evaluation of completed schemes, as well as the evaluation of policies and targets aimed at encouraging greater levels of walking and cycling.

12. Fixed Versus Variable Trip Matrices

12.1 Overview

TUBA software can utilise either fixed or variable trip matrices. The requirement for variable demand matrices is discussed in detail in PAG Unit 5.1 – Construction of Transport Models.

In traffic modelling, the number of trips in the demand matrix is fixed between the Do-Minimum and Do-Something in situations when only the first reaction, reassignment, takes place.

When it can be demonstrated that a scheme, or combination of schemes, is likely to cause a significant response other than reassignment, the fixed trip matrix assumption may be inappropriate, and the Do-Something and Do-Minimum traffic demand will differ.

TUBA calculates journey times from the traffic model and therefore is regarded as less liable to user error than other manual methods. With TUBA, residual value can be calculated by a separate assessment of benefits from year 30 onwards (see Section 14 below for guidance on the residual value period).

The TUBA program is also designed to address CBA in the case of variable trip matrices and is the recommended software for such appraisals. The use of alternative methods will be subject to the agreement and approval of TII. TUBA requires time and distance 'skim' matrices to be extracted from the traffic model. Detailed information on the use of TUBA is provided on https://www.gov.uk/government/publications/tuba-downloads-and-user-manuals.

Collision benefits should be calculated using a COBALT model, or in the absence of a traffic model, and subject to TII approval, through manual spreadsheet analysis using default collision rates and costs from PAG Unit 6.11 - National Parameter Values Sheet.

Further guidance on undertaking a preliminary assessment as to whether the fixed trip matrix assumption is valid can be found in PAG Unit 5.1 - Construction of Transport Models.

13. The CBA Method

13.1 Overview

Traffic flows with and without a scheme in place under appraisal are obtained from a transport modelling process that is carried out separate from CBA. The transport model assigns trips to the transport network with and without the proposed scheme and forms the basis of the input to CBA. The technique appropriate for this assignment will vary according to the particular scheme and specific guidance on traffic modelling is provided in PAG Unit 5.0 - Transport Modelling Overview.

In developing a CBA, the TUBA program requires skim matrices produced by the transport models relating to demand, travel time, travel distance and any toll charges or fares between each origin and destination. User benefits in terms of changes in travel time and VOC are calculated for each journey as a whole based on outputs from the transport model, rather than on a link-by-link basis. The skim matrices may be disaggregated to represent different user groups and travel modes, depending on the complexity of the transport model.

TUBA is the preferred approach for appraisal of all major TII schemes. As previously noted, the TII REM is the preferred approach for calculating emissions impacts on TII schemes and should replace the outputs generated by TUBA both in terms of tonnage changes and monetised changes. In addition the TII TEAM tool can calculate CBA for active travel scheme either as a standalone CBA or in addition to TUBA as part of a multi-modal project.

Guidance on using the TUBA programme is provided in PAG Unit 6.3 - Guidance on Using TUBA.

14. Appraisal Period

14.1 Overview

CBA considers the benefits arising over the 'life' of a project allowing a sounder basis for evaluation than is afforded by single year measures. Such measures can be particularly deceptive since two scheme options may yield similar returns for a given year but perform differently as traffic flows change over time.

The appraisal period is the period over which costs and benefits are calculated. The appraisal period for major TII schemes is currently set at 30 years unless otherwise agreed with TII.

It is recognised that some projects, particularly traffic management or Intelligent Transport Systems, may be designed with an initial design life for equipment of less than 30 years and in such circumstances the actual design life should be used as the appraisal period. However, traffic management or ITS projects may be intended to have serviceable lives considerably in excess of the design life of the equipment involved. Where periodic replacement of equipment and consumable infrastructure is required to ensure the serviceability of the project, the proper consideration of maintenance and operation costs throughout the appraisal period which will include such periodic re-investment may allow a 30-year appraisal period to be used.

In addition, the appraisal period for active travel or public transport scheme may vary and this needs to be taking into consideration when assess these schemes as part of multi-modal projects or standalone schemes.

15. Residual Value

15.1 Overview

In the appraisal of capital projects, the TAF states that a 30 year appraisal period should only be used where the life of an asset is at least 30 years. This is sensible, as it accepts that the benefits that flow from a scheme should only be appraised during the period when the infrastructure is available.

Nevertheless, where the lifespan of infrastructure is significantly in excess of 30 years, it is necessary to acknowledge this in scheme appraisal. Rather than increase the appraisal period, it is possible to quantify the likely benefits beyond the 30-year period through the definition of a 'Residual Value'.

The TAF specifies two approaches to calculating residual values: the project appraiser should agree the approach to be taken with TII in advance.

The approaches are summarised as:

- The NPV of the infrastructure over a period beyond the appraisal period
- The residual capital value may be viewed as equal to the original capital cost of the infrastructure, where maintenance and renewal activities in the first 30 years are sufficient to ensure that the infrastructure will continue to provide an identical level of service over the long term in the post 30 year period

For major transport schemes, the residual value is a measure of the NPV of the infrastructure over a specified period beyond the 30-year appraisal period. This is directly relative to the residual life of a scheme, which can range from no residual life at all, to quite a long residual life (greater than 100 years). Nevertheless, the definition of residual life also needs to account for the effect of the discount rate in reducing the present value of benefits that can arise.

Consider the example below in Figure 6.1.7 for a scheme of indefinite life, where a benefit of €1 accrues each year over a 100 year period at a discount rate of 5%. From year 0 to year 30, a little over 75% of the overall benefits are accrued, rising to 95% by year 60. Beyond the 60-year period, the final 5% of the total benefit is accrued.

This suggests that for projects with a long life span, the benefits accruable beyond the 30 year appraisal period can be significant. It also suggests, that although benefits can continue to be accrued for projects with indefinite life, there is little to be gained by accounting for any benefits beyond 60 years from opening.

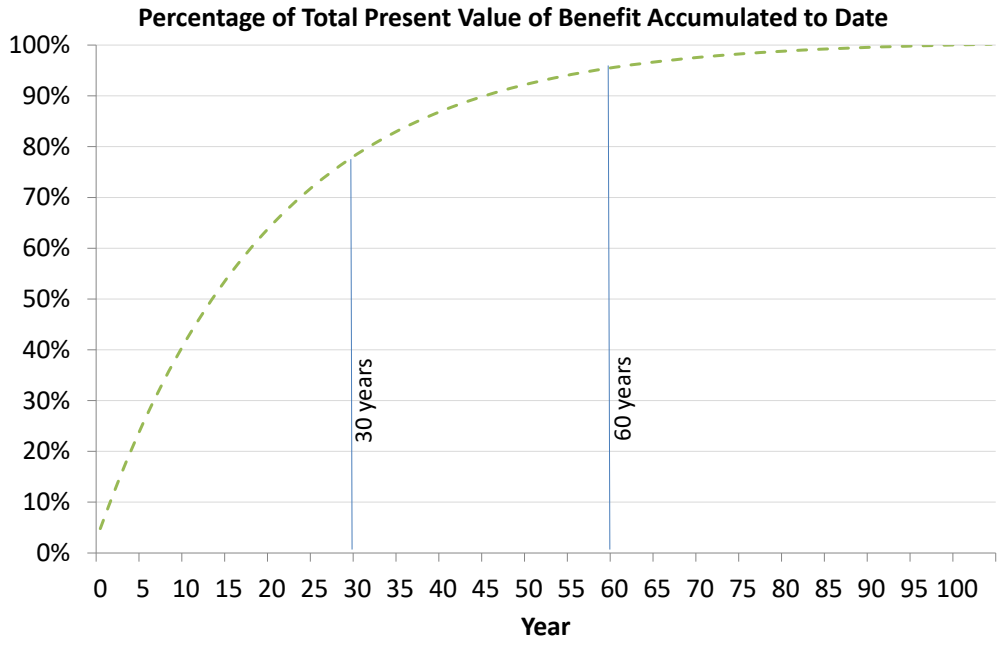

Figure 6.1.7 Accrual of Benefits Example

Obviously, there will be projects where the residual value will be curtailed due to the increasing cost of maintenance beyond a defined period, or the need for full reconstruction. For those projects, the periods within which the residual value should be calculated should ideally represent that period within which normal operation of the infrastructure (with a reasonable expenditure on maintenance) might be expected.

On this basis, the recommended period for the residual value calculation for infrastructure is set out in the Table 6.1.2.

Table 6.1.2 Period for Calculation of Residual Value

Category	Examples	Residual Value Period*
Long Life	Bridges, structures, tunnels, earthworks, greenways, bus-lanes, cycle lanes and other major investment in offline improvements	30
Moderate Life	Pavements or other online network rehabilitation on existing roads, where the design is such that no further major rehabilitation is required within a 40-year period	10
Short Life	Intelligent Transport Systems or other Traffic Management Solutions	0

** This relates to residual value calculated beyond the 30 year appraisal period*

The present value of the residual life should be included within the calculation of the overall NPV and the BCR of the scheme.

Although residual value can be incorporated into the reporting of benefits during scheme appraisal, the net present residual value should also be reported as a separate item in an appraisal summary table.

16. Treatment of Parameter Values

16.1 Overview

COBALT, TUBA, TII TEAM and the TII REM contain a series of default parameters relating to items such as economic values (for example; time, collisions, vehicle operating costs, emissions), collisions (rates and severity), annual traffic flow patterns and vehicle composition. Default values for the parameters can be found in PAG Unit 6.11 - National Parameter Values Sheet.

When undertaking TUBA assessments, the standard economics file must be amended to overwrite values specific to the UK with those suitable for CBA assessments in Ireland. A default economics file is provided in PAG Unit 6.5 - TUBA & COBALT Standard Input Files.

Economic input parameters do not change by project phase; however the treatment of other parameters is dependent on the phase of scheme development. Guidance on the source for each parameter and whether local or national default values should be used. Where local (i.e. non default) values are required, the user must update the relevant fields in the input file.

In the future, the real value of a number of parameters will change. PAG Unit 6.11 - National Parameter Values Sheet provides information on the growth factors that are to be applied to the value of time and the value of collisions. These factors are derived from forecast growth in real gross national product per person employed.

17. Risk Assessment & Sensitivity Tests

17.1 Risk Assessment

The Guidance under the TAF proposes that a 'Risk Register' should be developed and this should be updated and used continuously throughout the project. TAF recommended fields to include in a risk register can be found in Section 7.9.3 of TAF and include;

- Name of risk
- Brief description of the risk
- Risk owner
- Risk likelihood
- Risk impact, and
- Brief description of risk mitigation and management decisions

Furthermore, the possible impact and likelihood of each risk must be assessed based on past experience and foreseeable changes. In the case of TII, detailed guidance on broader risk assessment is set out in the Cost Management Manual (2023)[5] and the Project Management Guidelines. TII Strategic & Transport Planning team should be consulted before commencing with risk analysis to agree the approach to be taken.

Nevertheless, risks and uncertainty should be accounted for in conducting a CBA. This is primarily undertaken through sensitivity analysis, which shows the range of CBA results that would be expected for changes in a variety of the inputs.

Risk Mitigation

A plan to respond to the risks identified should be prepared. This may include the decision to tolerate certain risks (for example if the cost of risk mitigation is greater than the benefits to be gained), options for transferring risks and/or employing controls to prevent/guarantee outcomes or to minimise risk likelihood/impact, or the decision to terminate certain elements of the project if the threat to Value for Money is too great to bear.

Contingencies

Cost estimates should contain contingencies for unforeseen risks. This may be reduced as the appraisal period progresses and design becomes more certain. This is discussed further in the Project Management Guidelines.

17.2 Sensitivity Testing

Sensitivity testing is the process of establishing which outcomes of the appraisal are sensitive to the assumed values used in analysis. It is required under the DoT Transport Appraisal Framework (2023) and minimum of the following four types of test have been mandated.

[5] https://www.tiipublications.ie/library/PE-PMG-02041-05.pdf

Table 6.1.3 Sensitivity Test

Test	Sensitivities
Costing	Schemes should be appraised using both Target Cost and Total Scheme Budget. Cost estimate risk is discussed in more detail in the Cost Management Manual.
Demand	Schemes should be appraised using central and low and high sensitivity growth forecasts as set out in PAG Unit 5.0.
Benefits	Where the quantification of benefits is regarded as subject to error (e.g. decongestion benefits, bespoke modelling tool utilised) these should be subject to tests of plus and minus 10% and 20%.
Complementary and Substitute Proposals	The project being assessed within the CBA may be affected by proposals for other projects if these are complements or substitutes for the proposal in hand. In cases where complements and substitutes are already fully committed, these are incorporated within the do-minimum or do-nothing scenarios against which the proposed scheme will be evaluated. In certain circumstances should proposals for complements or substitutes exist but have not yet reached the stage of being fully committed, then the potential impact of these on the outcome for the proposal in hand should be assessed. The need for this sensitivity test should be agreed with TII as part of the Appraisal Plan.
Non-Standard Parameters	If any non-standard parameters are used as part of the appraisal process, then their impact should be assessed and included as part of the sensitivity analysis.

Once the mandatory tests have been undertaken, it is worthwhile to undertake analysis to determine the ‘switching value’. This is the change in the risk factor that would eliminate the value of the project. For example, this metric might be presented as ‘a 40% increase in costs would reduce the NPV to zero’ or a ‘22% decline in passenger demand would mean that benefits no longer exceed costs’.

18. CBA Outputs

18.1 Overview

The CBA outputs are descriptions and summaries of the methodologies employed, estimates and assumptions made and the results of the analysis. The CBA outputs allow the options being considered to be compared in light of the sensitivities within the CBA. These will then inform the preferred option decision and recommendation.

18.2 CBA Report

The purpose of the CBA report is to detail and justify the methodology, provide detailed information on the data inputs and to present the results of the economic appraisal.

The CBA report is the primary output from the CBA process and will contain information required to undertake an audit as set out in PAG Unit 6.6 - CBA Audit Checklist i.e. maps; input and output files for each scenario tested, and any other information requested. Guidance on the contents of a CBA Report is contained in PAG Unit 6.7: CBA Report and PAG Unit 6.6: CBA Audit Checklist.

TUBA provides summary output tables that form the basis of the CBA results required for the CBA Report and Multi-Criteria Analysis:

- **Transport Economic Efficiency** (TEE) Table - contains the costs and benefits incurred by both users and operators of the transport system. Costs incurred by Government are not included in this table; instead these are reported in the Impact on the Public Accounts;
- **Impact on the Public Accounts** – the present value of the scheme costs is summarised in this table, which documents the net cost to Government after taking into account the contributions towards the scheme cost from other sources, revenues received from tolls and income received from changes in indirect taxation. This table provides the information required to undertake the Exchequer Cash Flow Analysis; and
- **Analysis of Monetised Costs and Benefits** – within this summary output table, all the benefits from the scheme that can be expressed in monetary form are arranged to derive the NPV and BCR.

COBALT provides the summary output data that forms the basis of the CBA results in relation to collision reduction required for the CBA Report and Multi-Criteria Analysis:

- **Economic Summary** – presents the total costs of collisions over the appraisal period for the Without-Scheme and With-Scheme scenarios
- **Collision Summary** - provides the total number of collisions over the appraisal period for the Without-Scheme and With-Scheme scenarios
- **Casualty Summary** - provides the total number of casualties over the appraisal period for the Without-Scheme and With-Scheme scenarios

The TII REM provides the summary output data that forms the basis of the CBA results in relation to change in emissions for the CBA Report and Multi-Criteria Analysis. These should replace the emissions change generated by TUBA for use in CBA and MCA. In addition the TII TEAM tool provides economic inputs to the CBA process for active travel, which can be used to supplement the CBA in TUBA for scheme which included an active travel element.

Where there are significant costs and benefits that could not be monetised, comments outlining these factors and their implications should be included as a part of the Business Case and in the MCA Such comments should be included below the BCR to alert the reader to the impact of basing decisions solely on the monetised elements in the CBA and, if necessary, to indicate the requirement for additional qualitative information.

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