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Project Appraisal Guidelines for National Roads Unit 6.1 - Guidance on conducting CBA

PE-PAG-02020
October 2016

PE Planning & Evaluation

Technical

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TII Publication Title	*Project Appraisal Guidelines for National Roads Unit 6.1 - Guidance on conducting CBA*
TII Publication Number	*PE-PAG-02020*

Activity	*Planning & Evaluation (PE)*	**Document Set**	*Technical*
Stream	*Project Appraisal Guidelines (PAG)*	**Publication Date**	*October 2016*
Document Number	*02020*	**Historical Reference**	**PAG Unit 6.1**

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TII Publications

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1. Introduction

Cost Benefit Analysis (CBA) forms one element of the appraisal process for road 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 road scheme is economically viable; i.e. whether economic benefits resulting from the provision of a 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 road 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 now required for all transport projects with estimated lifetime costs in excess of €20 million. This requirement is stipulated by the Department of Public Expenditure and Reform (DPER) under the Public Spending Code and the Department of Transport Tourism and Sport (DTTAS) under the Common Appraisal Framework (CAF) for Transport Projects and Programmes, March 2016.

Central government is now involved in the preparation of business cases at two key stages:

- Before starting a preliminary appraisal, assumptions and constraints should be agreed with the Economic and Financial Evaluation Unit (EFEU) unit of DTTAS via the Project Appraisal Plan (PAP);
- Completed Business Cases should be submitted to the relevant DTTAS line division, and then passed on the Central Expenditure Evaluation Unit (CEEU) unit of DPER for their view before the Sanctioning Authority gives approval in principle; and
- For projects costing over €20m the Sponsoring Agency/Sanctioning Authority should seek the advice of the NDFA on financing options, including PPP.

Elements of the CBA may be used to satisfy the requirement within the appraisal process to undertake an exchequer analysis, 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).

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

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; and

v) Making a recommendation to the Sanctioning Authority.

Guidance on the theory and practice of CBA specifically for road schemes are provided within this Unit.

2. Cost Benefit Analysis (CBA): Principles and Economic Theory

2.1 Why use CBA?

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.

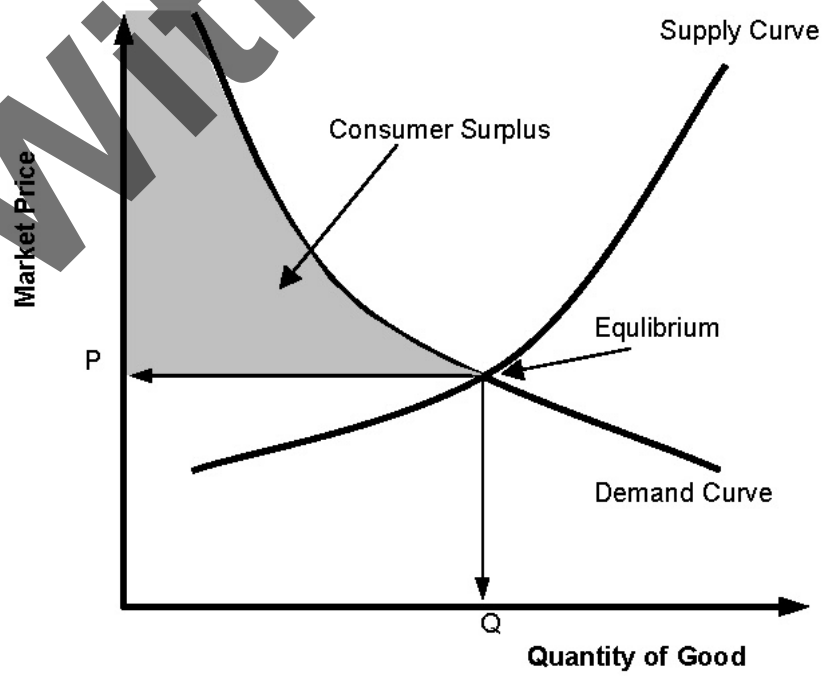
Governments need to be able to understand the value for money of different expenditure programmes (e.g. comparing road schemes with investment in other transport projects), to identify priorities within a single programme (e.g. comparing different road schemes) and to understand if individual projects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

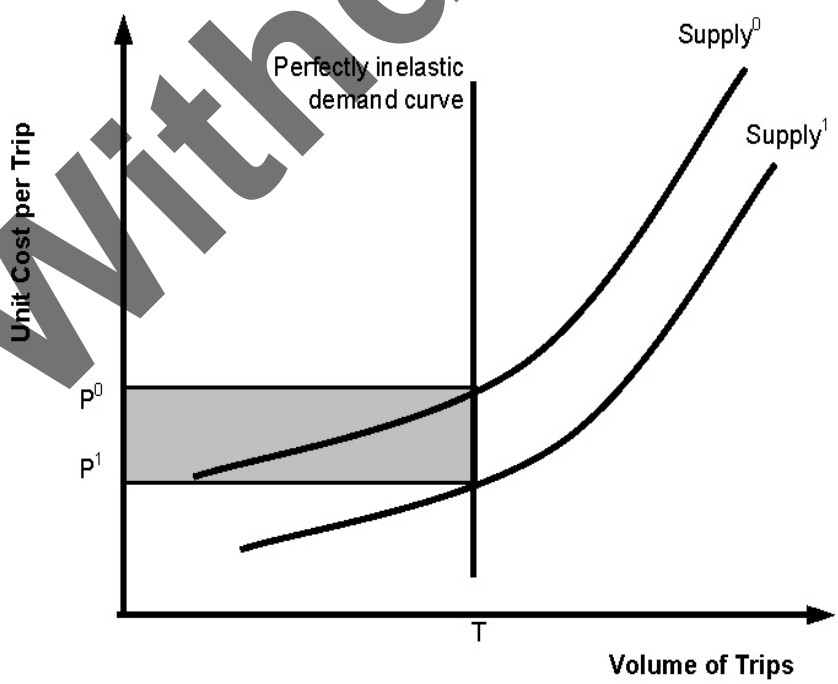
If travel demand remains unchanged (i.e. demand is perfectly inelastic, meaning totally unresponsive to changes in price), but travel costs change, the change in consumer surplus is represented by the shaded area in Figure 6.1.2, and defined by the following formula:

$$\text{Change in consumer surplus} = (P^0 - P^1) * T$$

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

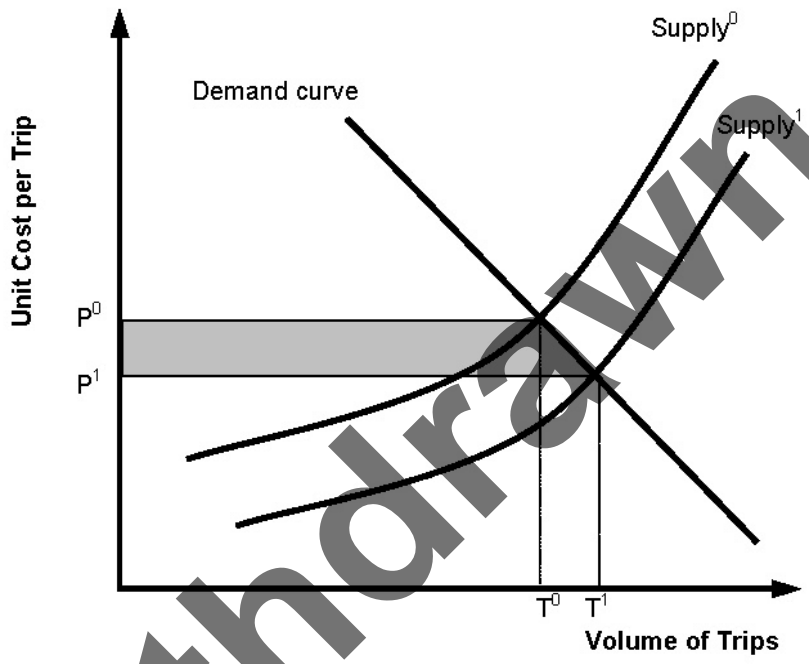


In the case where demand changes as result of changes in travel costs (i.e. demand is not perfectly inelastic), then the change in consumer surplus is as shown in Figure 6.2.3 and defined by:

$$\text{Change in consumer surplus} = (P^0-P^1)T^0 + \tfrac{1}{2}(P^0-P^1)(T^1-T^0)$$
$$= \tfrac{1}{2}(T^0+T^1)(P^0-P^1)$$

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); and
- 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").

TII recommends a 2011 price base year in line with the Department of Transport Tourism and Sport (DTTAS) Common Appraisal Framework (2016).

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 currently mandated by Department of Public Expenditure and Reform (DPER) is 5%. This is the discount rate that should be employed in all road project appraisals.

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:

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

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:

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

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:

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

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:

$$NPV = PVB - PVC$$

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:

$$BCR = PVB / PVC$$

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 7.1: Project Appraisal Balance Sheet, 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)?; and
- 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 appraisal software (TUBA) already outputs the required summary tables in WTP in market prices.

3. Application of CBA to Road Schemes

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

- Concept & Feasibility Studies;
- Option Selection;
- Design and Environmental Evaluation;
- Enabling and Procurement; and
- Closeout and Review.

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

3.1 Concept & Feasibility Studies

At this phase, a number of alternatives for the investment of public money to solve an identified problem must be considered. If the problem is a congested area of the transport network, the alternatives to be considered may include a new road scheme, an upgraded road scheme, a management option or a public transport option. A preliminary assessment of the costs and benefits of each alternative is required in order to select the appropriate type of scheme. Further information on alternatives is contained within PAG Unit 4.0 – Consideration of Alternatives & Options.

In certain circumstances, the initial selection of options, in terms of the type of scheme required, will have been undertaken as part of a wider transportation strategy such as the TII National Roads Needs Study or a regional transport strategy prepared by the National Transport Authority. In these cases, an appropriate reference to this process should be adequate at this phase. This should be agreed with DTTAS as part of Pre-Appraisal Stage.

Where an overarching transport strategy does not exist, or is not up to date, a CBA will be required at the scheme concept & feasibility phase. This CBA will be undertaken at a very high level as limited detail of scheme costs and scheme alternatives will likely be available.

It is envisaged that the CBA will, in very broad terms, provide an assessment as to the range of benefits that could be expected from each alternative and compare that with a broad range of expected costs. The assessment should conclude that a specific alternative would represent the most economically worthwhile type of scheme. A BCR calculation should not be produced, given the lack of information available.

3.2 Option Selection

At this phase, option comparison cost 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. PAG Unit 4.0 provides guidance on the selection of scenarios for the option selection phase. For all alternatives, the CBA process must be undertaken for the high, medium and low growth scenarios.

3.3 Design and Environmental Evaluation

The CBA at this phase is more detailed, using local parameter values for traffic composition and, perhaps, local collision rates. More robust scheme cost estimates will 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 Enabling and Procurement

A revised CBA is to be carried out at the Enabling and Procurement phase if the tender price is notably different from that envisaged or if the project scope has changed on foot of changes in planning agreements.

At this stage the CBA must also be run (at least) six times, one for each combination of traffic growth ('high', 'central' and 'low') and cost estimate (Total Scheme Budget and Target Cost 2). Toll schemes should focus on the tolled scenario, including all relevant costs such as the operation costs of the toll collection system.

3.5 Closeout and Review

The purpose of the Closeout and Review phase CBA is to determine how the outturn costs and actual post-opening traffic flows 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. The final account / closeout CBA should use actual scheme costs and traffic values. The CBA at this phase should use, insofar as possible, the same parameters used in the design and Enabling and Procurement CBAs. 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

The analysis of monetised costs and benefits is currently limited to the assessment of the following core impacts:

- Changes in travel time;
- Changes in vehicle operating costs;
- Changes in tolls;
- Changes in scheme costs and maintenance expenditure;
- Delays and emissions during construction and maintenance;
- Changes in collision costs; and
- Changes in emissions of greenhouse and non-greenhouse gases.

These are described in more detail in Sections 5 to 10 of this document.

Table 6.1.1 sets out those impacts of a road scheme that are not monetised; instead these are to be assessed qualitatively according to the guidance provided in PAG Unit 7.1: Project Appraisal Balance Sheet (PABS).

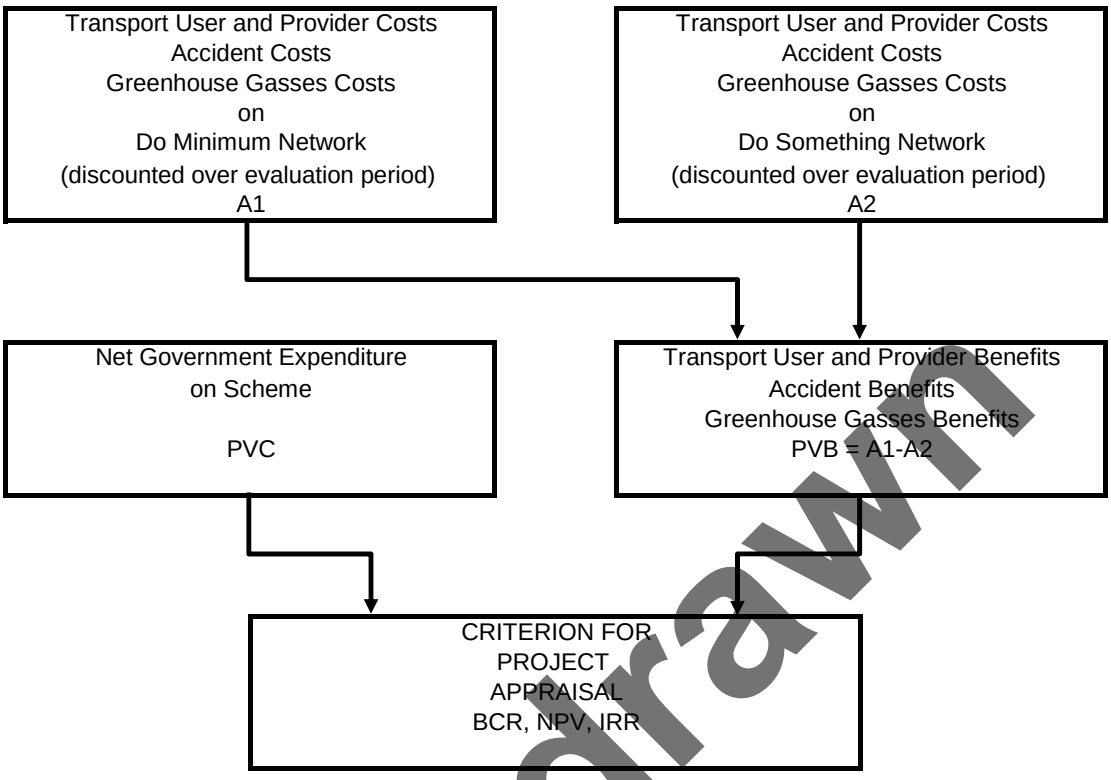
Table 6.1.1: Non-Monetised Impacts in the Appraisal of Road Scheme

Criterion	Element
Environment	Air Quality Noise and vibration Landscape and visual quality Biodiversity Cultural heritage Land use Water resources
Safety	Security
Economy	Other economic impacts
Accessibility and Social Inclusion	Impact on vulnerable groups Impact on deprived geographic areas
Integration	Transport integration Land use integration Geographical integration Integration with other Government policies
Physical Activity*	Summary of nature of physical activity impacts including impacts on particular groups of road users

**Applicable to schemes with active mode elements only*

Figure 6.2.4 illustrates how the costs and benefits of a scheme are brought together in the overall appraisal of monetised benefits.

Figure 6.2.4: Overview of the CBA Appraisal Process



5. Values of Time

Travel time savings are the major items of the calculated benefit resulting from a typical road scheme.

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; and
- 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 infrastructure projects are provided in PAG Unit 6.11: National Parameter Values Sheet. These are in line with parameters provided by the Department of Transport, Tourism and Sport in the Common Appraisal Framework for Transport Projects and Programmes.

6. Vehicle Operating Costs (VOC)

The use of the road system by private cars and 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

Any additional charges resulting from tolls 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.

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

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

- Investment costs (including construction, land, labour, preparation and supervision costs); and
- 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.

8.1 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; and
- 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 Project Appraisal Balance Sheet, is taken from standard output files produced by the COBALT and TUBA programs.

8.2 Shadow Prices

Current guidance from the Department of Transport Tourism and Sport (DTTAS) Common Appraisal Framework (2016) requires that a shadow price factor of 1.3 should be adopted for public funds. The CAF mandates that economic appraisals in the transport sector should be estimated in the basis of a shadow price of labour of 0.8 with a sensitivity analysis on the upper bound of the scale (shadow price of labour of 1.0).

8.3 Costs during Construction and Maintenance

Delays to road 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

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 Department of Transport, Tourism and Sport in the Common Appraisal Framework for Transport Projects and Programmes.

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

10. Emissions

Emissions should be considered in terms of the change in the equivalent tonnes of gas released as a result of implementing a road 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 PABS, 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. The appraisal process using TUBA automatically calculates the change in emissions for a number of greenhouse gases and non-greenhouse gases for the appraisal period.

The construction of a road scheme also generates emissions resulting from the manufacturing and construction process. These are not usually included in the standard appraisal process.

11. Fixed Versus Variable Trip Matrices

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.

12. The CBA Method

Traffic flows with and without the road scheme under appraisal are obtained from a transport modelling process that is carried out separate from CBA. The transport model assigns trips to the road network with and without the proposed road 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. The use of COBA is no longer accepted for the appraisal of major national road schemes.

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

13. Appraisal Period

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 National Road 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.

14. Residual Value

In the appraisal of capital projects, the Department of Transport Tourism and Sport (DTTAS) Common Appraisal Framework (CAF) 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 CAF 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:

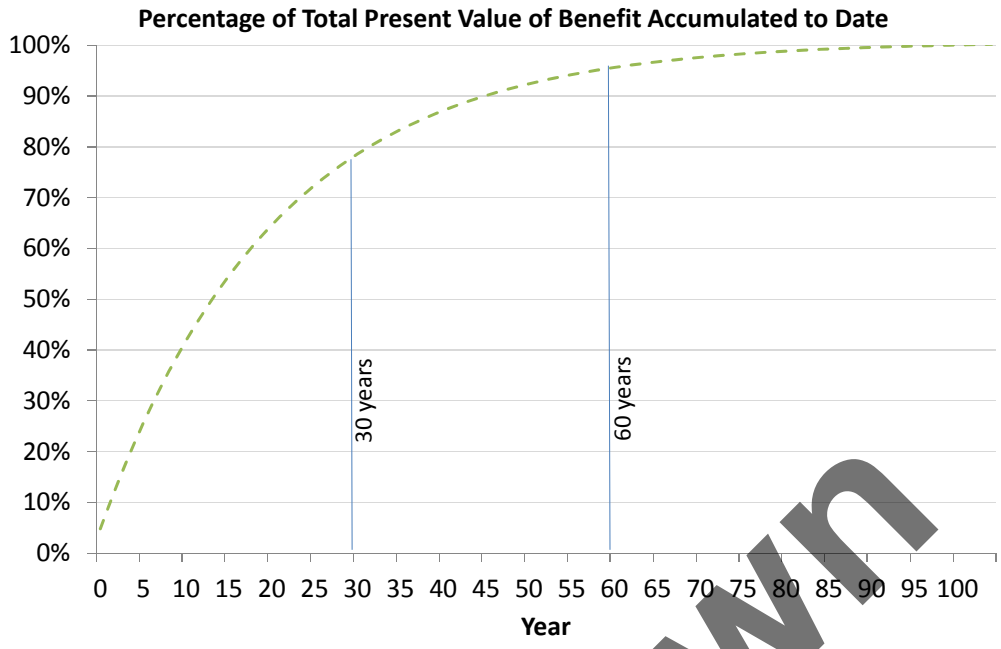
i) The NPV of the infrastructure over a period beyond the appraisal period.

ii) 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 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 6.1.5: Accrual of Benefits



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 below.

Table 6.1.2: Period for Calculation of Residual Value

Category	Examples	Residual Value Period*
Long Life	Bridges, structures, tunnels, earthworks 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.

15. Treatment of Parameter Values

COBALT and TUBA contain a series of default parameters relating to items such as economic values (for example; time, collisions and vehicle operating costs), 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.

16. Risk Assessment

As set out under the Common Appraisal Framework (2016) a key component of a CBA is the identification of the risks associated with the viable options. TII Strategic & Transport Planning team should be consulted before commencing with risk analysis to agree the approach to be taken.

The Guidance under the Common Appraisal Framework (2016) proposes that in the first instance a 'Risk Register' should be developed and this should be updated and used continuously throughout the project. 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 (2010) and the Project Management Guidelines.

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.

17. Sensitivity Tests

Sensitivity testing is required under the DTTAS Common Appraisal Framework (2016) and minimum of the following 4 types of test have been mandated:

Table 6.1.3: Sensitivity Tests

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 low, central and high 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 Project Appraisal Plan.

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'.

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.

18. CBA Outputs

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.

18.1 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 Project Appraisal Balance Sheet (PABS).

- **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 are 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 road 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 Project Appraisal Balance Sheet (PABS).

- **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; and
- **Casualty Summary** - provides the total number of casualties over the appraisal period for the Without-Scheme and With-Scheme scenarios.

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 PABS. 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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