Chapter 2 Basic concepts

2.1 Overview

Introduction

This chapter describes the basic concepts underlying the economic efficiency evaluation procedures for projects and packages of projects submitted to Land Transport NZ for funding.

In this chapter

This chapter contains the following topics:

2.2 Social cost benefit analysis and financial analysis

Social cost benefit analysis and financial analysis

For conventional business investment, an analysis is made of the initial investment costs against the revenue from sales, less operating expenses. If the returns on the investment justify the investment costs, and cash flow forecasts are satisfactory, then the venture is considered worthwhile from a business viewpoint. This is termed financial analysis.

Social cost benefit analysis (generally abbreviated to cost benefit analysis) is similar to financial analysis except that a national viewpoint is adopted in which the benefits and costs are those to the nation as a whole. This viewpoint is appropriate in the case of transport projects, which are undertaken on behalf of the nation and are publicly funded.

The analysis involves determining the various benefits and costs associated with each project alternative and option over a certain analysis period, to determine the relative economic efficiency of these alternatives and options. The results for the chosen alternative and option indicates whether the project is worthwhile from an economic efficiency viewpoint.

Economic costs and shadow pricing

A financial analysis considers the monetary costs and revenues to the business contemplating the investment. These monetary costs are the prices of goods and services in the marketplace.

In many instances the market prices for goods and services do not equate to their economic costs (also termed national resource costs). This difference may occur from transfer payments, such as taxes, duties and subsidies, or of market imperfections such as monopolistic pricing or other factors.

It is necessary, when performing a cost benefit analysis, to substitute the market price of items with a value that takes account of these differences. This technique is termed shadow pricing.

The benefit values provided in this manual take account of the differences between market prices and national resource costs, and therefore do not require any adjustment.

All construction and maintenance cost estimates used in economic evaluations must exclude GST, so that they are national resource costs.

2.3 Benefits

Types of benefit

Three types of benefit (or disbenefit) are considered in economic evaluations of transport projects:

- benefits with monetary values derived from the marketplace, eg, vehicle operating costs and the value of work travel time
- benefits that have been given a standard monetary value, eg, the statistical value of human life, the value of non-work travel time, the comfort value gained from sealing unsealed roads, the frustration reduction benefit from passing opportunities and the carbon dioxide reduction benefit
- benefits that have not been given a standard monetary value, either because it is inappropriate or it has not been possible to establish a standard value, eg, cultural, visual or ecological impact.

Benefits of transport projects may accrue to both transport users and other parties. Disbenefits are treated as negative benefits.

Assignment of benefit value

Market-based monetary values for the major land transport benefits are provided in this manual. Appendix A8 provides standard monetary values for several external impacts.

There are various techniques that allow economic values to be assigned to benefits, eg, willingness to pay, avoidance or mitigation costs. Where benefits that do not have monetary values in this manual are considered likely to be significant, it may be desirable to undertake such an analysis.

Where no monetary value is available, the benefits should be described and where possible quantified, and also reported as an input into Land transport NZ's funding allocation process (refer to chapter 6 of Land Transport NZ's *Programme and funding manual*).

Level of data collection and analysis

Generally, all project benefits should be included in the economic analysis. In some cases there are practical limits to the amount of time and energy that can or should be spent in gathering information and calculating total project benefits. If a particular parameter is likely to contribute only a small amount of the total projects benefits, it is unwise to spend significant effort in obtaining this information and the use of the default values contained in appendix A2 may be appropriate. Projects should be considered on a case-by-case basis to determine the appropriate level of data collection and analysis to apply.

2.3 Benefits, continued

Primary benefits

The primary benefits used in economic efficiency evaluation of land transport projects are listed below showing the type of project in which they are normally taken account of.

Primary benefit	Road	Transport demand management	Transport services	Walking and cycling	Education promotion and marketing	Parking and land use	Private sector financing and road tolling
Travel time cost savings	✓	✓	✓	✓	✓		
Vehicle operating cost savings	✓	✓	✓	✓	✓		
Accident cost savings	✓	✓		✓	✓	✓	
Seal extension benefits	✓						
Driver frustration reduction benefits	✓						
Risk reduction benefits	✓	✓	✓		✓		✓
Vehicle emission reduction benefits	✓					✓	
Other external benefits	✓	✓	✓	✓	✓	✓	✓
Mode change benefits		✓	✓	✓	✓		
Walking and cycling health benefits		✓		✓			
Walking and cycling cost savings		✓		✓	✓		
Transport service user benefits			✓			✓	
Parking user cost savings		✓			✓	✓	
National strategic factors	✓	✓	✓		✓		

Secondary benefits

The benefits of traffic congestion reduction and improved trip reliability are accounted for by adjusting the primary benefits:

- travel time cost savings
- vehicle operating cost savings
- carbon dioxide reduction benefits.

Combined benefit values

In some simplified procedures, benefit values consisting of combinations of primary benefits are used to simplify the calculations.

2.3 Benefits, continued

National strategic factors

When evaluating projects it is expected that most, and in many cases all, of the benefits will relate to the monetised and non-monetised impacts described in this section and 2.5. However, despite the wide range of factors currently taken into account, there may also be certain national strategic factors that should be included in the analysis, particularly for large projects.

National strategic factors are defined as national benefits that are valued by transport users or communities, but are not included elsewhere in the procedures in this manual. National strategic factors may be incorporated as benefits in the evaluation of a project where they:

- will have a material impact on a project's importance
- comprise national economic benefits
- have not already been counted in the core analysis
- would likely be valued in a 'normal' market.
- The criteria for assessing national strategic factors and their valuation are discussed in more detail in appendix A10.

National strategic factors currently recognised by Land Transport NZ for road projects are described in section 3.5 of this volume. National strategic factors for transport demand management projects are identified in section 3.8 of volume 2 and for transport services proposals in section 7.6 of volume 2.

Other national strategic factor categories may be added to the list over time (particularly where project promoters can show that transport users are willing to pay for a benefit not included in the current procedures), as long as they can be shown to meet the criteria above. Land Transport NZ will consider other potential instances of national strategic factors on a case-by-case basis.

Economies of scale

In some rare situations, it is possible that increased economic activity within an area resulting from a transport improvement may give rise to economies of scale and, therefore, additional economic efficiency improvements. If these efficiency improvements can be clearly identified, they can also be included as benefits in the analysis.

If economies of scale are considered, care must be taken to ensure:

- only the efficiency gain as a result of the economies of scale is included as an additional benefit
- there are no diseconomies of scale created in other areas as a result of transferred economic activity
- there is a clear connection between the efficiency gain and the project being evaluated.

2.3 Benefits, continued

Business benefits

Benefits to businesses are economic transfers rather than national economic benefits and are therefore not included in the economic efficiency calculation. However, they may be quantified and reported as part of the funding allocation process where appropriate – refer to chapter 6 of Land Transport NZ's *Programme and funding manual*. This is particularly relevant to transport demand management projects.

Double counting of benefits

The standard benefits listed in this manual generally constitute the total economic impact of improved levels of service, accessibility or safety. Certain external impacts of projects, such as increased land values, may arise because of the improved level of service and accessibility to nearby areas. These impacts shall be excluded from the evaluation because including them would be double counting.

For example, it would be double counting to claim increased land values as additional benefits if these benefits are merely a capitalisation of road-user benefits. In the case of a TDM project, it would be double counting to include 'saved energy' benefits, vehicle operating costs savings and travel time savings in the same evaluation.

Disbenefits during implementation/ construction

Disbenefits considered in the economic evaluation may be restricted to travel time delays only, and do not need to include vehicle operating costs, accident cost, noise, dust, etc.

Where the project/option is offline and the disruption is minimal, there is no need to incorporate the disbenefits in the economic evaluation. Where the impact of disruption is material then the disbenefits of the project/option need to be included in the evaluation.

The impact should be determined through sensitivity analysis, eg. a preliminary estimate of the disbenefits to adjust the BCR. If the adjusted BCR remains within its funding profile level (low, medium, or high), then there is no need to undertake a detailed evaluation of the disbenefits, provided the difference between the BCRs is less than 10%. However, if the adjusted BCR falls to a lower profile level, which could impact the project's priority or funding source, then a detailed evaluation of the disbenefits needs to be undertaken. If the adjusted BCR falls more than 10%, regardless of the funding profile level, then a detailed evaluation should be considered.

Seek guidance from Land Transport NZ if there is any doubt whether or not disbenefits should be taken into account for a particular project.

2.3 Benefits, continued

Equity impacts

The cost benefit analysis methods described in this manual do not directly deal with the incidence of benefits and costs on different sections of the public. Cost benefit analysis only indicates those projects with the largest resource gains per dollars of expenditure, irrespective of whether benefits and costs are evenly distributed or whether costs fall more heavily on some sections of society while benefits accrue mainly to others.

Equity refers to how the benefits and costs of transport projects are distributed across population groups. There are four types of equity related to transport:

- egalitarianism – treating everybody the same, regardless of who they are
- horizontal equity – whether benefits, disbenefits, (including externalities) and costs are applied equally to people and groups in comparable condition
- vertical equity with respect to income – whether lower-income people bear a larger portion of the impacts
- vertical equity with regard to mobility needs and abilities – whether transport systems adequately serve people who are transport disadvantaged.

Methods to disaggregate impacts among socioeconomic groups or geographical areas include:

- spatially based analysis that uses spatial units, such as traffic-analysis zones or census tracts that can be classified by characteristic (income, predominate minority, etc)
- spatial disaggregation, where a geographical information system raster module is used to disaggregate socioeconomic data and impact data to grid cells
- micro-simulation that uses a set of actual or synthetic individuals or households that represent the population.

An analysis of the distribution of benefits and costs among different groups of people is not required for the economic efficiency evaluation of the project. However, reporting of the distribution of benefits and costs, particularly where they relate to the needs of the transport disadvantaged, is part of the funding allocation process.

2.4 External impacts

Introduction

External impacts are benefits or disbenefits stemming from a project that do not reside with the responsible government agencies, approved organisations or transport users. Because cost benefit analysis takes the national viewpoint, external impacts must also be considered.

Environmental impacts

Environmental impacts are an important subset of external impacts.

The *New Zealand Transport Strategy*, *Land Transport Management Act* and *Resource Management Act* impose a duty when preparing projects to assess the effect of the project on the environment and environmental sustainability. The emphasis is to 'avoid to the extent reasonable in the circumstances, adverse effects on the environment[1]' by:

- reducing the negative impacts of the transport system on land, air, water, communities and ecosystems
- ensuring the transport system will make more efficient use of its resources, reduce its use of non-renewable resources, and shift over time from non-renewable to renewable resources[2].

Quantifying and valuing external impacts

Most of the potential external impacts are discussed in appendix A8, which contains techniques for quantifying and, in some cases, valuing the impact. Benefits from sealing roads are addressed in simplified procedure SP4.

Where impacts are valued, they should be included as benefits or disbenefits in the economic efficiency evaluation. Non-monetised impacts should be quantified, where possible, and reported as part of the funding allocation process.

Mitigation of external impacts

Where a design feature to avoid, remedy or mitigate adverse external impacts is included in a project and the feature significantly increases the project cost, it shall be treated in the following way. If the feature is:

(a) required by the consenting authority in order to conform with the *Resource Management Act* or other legislation, then the cost of the feature shall be treated as an integral part of the project cost;

(b) not required by the consenting authority in order to conform with the *Resource Management Act* or other legislation, then the feature shall be described and evaluated in terms of benefits and costs, and the results reported in worksheet A8.2.

The costs of the preferred mitigation measure shall be included in the project cost.

[1] *Land Transport Management Act*, section 68(2)(a)

[2] *New Zealand Transport Strategy*, page 43

2.4 External impacts, continued

Transferred external impacts

External impacts are not included in the economic evaluation when these merely represent a transfer of impact from one person to another, eg, a change of traffic flow may benefit one service station at the expense of another. Although this may be a significant impact locally, from a national economic viewpoint the two impacts are likely to cancel each other out.

Also refer to *Equity impacts* in section 2.3.

2.5 Costs

Project costs

The costs taken into account in an economic efficiency evaluation depend on the type of project being evaluated.

Costs for road projects are identified in section 3.6 of this volume. Costs to be taken into account for transport demand management and transport services are listed in volume 2.

Sunk costs

Where expenditure on a project has already been incurred, it shall still be included in the evaluation if the item has a market value and this value can still be realised. Land is an example.

Costs irrevocably committed which have no salvage or realisable value are termed sunk costs and shall not be included in the evaluation, eg, investigation, research and design costs already incurred.

2.6 Present value and discounting

Introduction

The community places a higher value on benefits and costs that occur in the near future, compared with those that occur at a later date. Thus it is not possible to directly combine amounts occurring at different times.

Example

A present amount may be invested and is worth more than the same amount at some future time by its return on investment in the interim. For example, if it is known that $1.00 invested today will return $1.10 in a year's time, then we can say that $1.10 in a year's time has a present value of $1.00.

Treatment in cost benefit analysis

The time value of money is treated in cost benefit analysis by discounting benefits and costs to present values to provide a common unit of measurement. The discount rate represents the rate at which present benefits and costs can be exchanged for future benefits and costs.

Benefits and costs may occur at various times over the duration of a project and beyond.

Benefits and costs are discounted to take this timing into account using appropriate present-worth factors from appendix A1.

Present value

The present value (PV) or present worth of a future benefit or cost is its discounted value at the present day. For a series of annual benefits or costs, the discounted values for each future year are summed to give the present values of the series.

2.6 Present value and discounting, continued

Discount rate

The discount rate shall be 10 percent per annum. This is a rate established by The Treasury for all public sector project evaluations.

Use of discount factors

The discount factors for single payments, uniform series payments and arithmetic growth series payments in appendix A1 shall be used to calculate the PV of future costs and benefits. Appendix A1 also gives a detailed explanation of how the discount factors shall be applied. The single-payment discount factors in table A1.1 are in time steps of one year, and therefore part-year benefit and cost flows must be assigned to either the start or end of the financial year in which they occur, whichever is the nearer.

Particular care shall be taken with amounts occurring in the first five years of the analysis period to allocate them to the correct time. Table A1.2 provides single-payment discount factors in time steps of one quarter of a year, which allows improved accuracy. It is important to accurately define the start timing of the benefit flow after completion of construction/implementation.

Inflation

Price inflation is a different concept from discounting. In general, all benefits and costs should be calculated in present-day (constant) dollars.

The discounting of future values reduces the significance of any future inflation that might be expected to occur between various categories of benefits and costs, and therefore no adjustment for inflation is required in the evaluation.

2.7 Time frame

Time zero	Time zero (the date all benefits and costs shall be discounted to) is 1 July of the financial year in which the project is submitted for a commitment to funding. For example, if a project is submitted for a commitment to funding in the 2007/08 National Land Transport Programme (NLTP), time zero is 1 July 2007. All project options shall use the same time zero for evaluation, irrespective of whether construction for all options would commence at that time. In the case of projects being resubmitted in subsequent years, the evaluation shall be revised to the time zero appropriate to the year for which the project is being submitted for a commitment to funding.
Analysis period	The time period used in economic evaluation shall be sufficient to cover all costs and benefits that are significant in present value terms. The analysis period for road projects is described in section 3.7 of this volume and for transport demand management, transport services and other projects in volume 2.
Base date for costs and benefits	The base date for dollar values of project benefits and costs shall be 1 July of the financial year in which the evaluation is prepared. In the case of a project being resubmitted in subsequent years, all dollar values of benefits and costs shall be adjusted to the same base date. Factors for updating construction, maintenance and user benefits are given in appendix A12. Where land costs are significant, the most recent possible estimate shall be used. The base date for project benefits and costs need not coincide with time zero. Generally, the base date for dollar values will be one year earlier than time zero.

2.8 Do minimum and benefit and cost differentials

The do minimum

Most forms of project evaluation involve choices between different options or courses of action. In theory, every option should be compared with the option of doing nothing at all, ie, the *do nothing.*

For many transport projects, it is often not practical to do nothing. A certain minimum level of expenditure may be required to maintain a minimum level of service. This minimum level of expenditure is known as the *do minimum* and shall be used as the basis for evaluation, rather than the do nothing.

It is important not to overstate the scope of the do minimum, ie, it shall only include that work which is absolutely essential to preserve a minimum level of service.

Particular caution is required if the cost of the do minimum exceeds a relatively small proportion of the cost of the options being considered. In such cases, the do minimum should be re-examined to see if it is being overstated.

Future costs in the do minimum

In cases where the do minimum involves a large future expenditure, the option of undertaking the project now should be compared to the option of deferring the project until this expenditure is due. Similarly, if the capital cost of the project is expected to increase for some reason other than normal inflation, again the option of undertaking the project now should be compared with the option of deferring construction and incurring the higher cost.

Benefit and cost differentials

The project costs required for determining benefit cost ratios (section 2.9), incremental benefit cost ratios (section 2.10) and first-year rate of return (section 2.11) are the differences between the costs of the project option and the costs of the do minimum. The project benefits are similarly the differences between the benefit values calculated for the project option and those of the do minimum.

It follows that where a particular benefit or cost is unchanged among all the project options and the do minimum, it does not require valuation or inclusion in the economic analysis.

2.9 Benefit cost ratios

Introduction

The benefit cost ratio (BCR) of a project is the present value (PV) of net benefits divided by the PV of net costs. A project is regarded as economic or worthy of execution if the PV of its benefits is greater than the PV of its costs, ie, a project is economic if the BCR is greater than 1.0.

National benefit cost ratio

Land Transport NZ uses the national benefit cost ratio (BCR_N) as a measure of economic efficiency from a national perspective.

In its basic form, BCR_N is defined as:

$$BCR_N = \frac{\text{present value of national economic benefits}}{\text{present value of national economic costs}}$$

where:

national economic benefits	=	net direct and indirect benefits and disbenefits to all affected transport users plus all other monetised impacts.
national economic costs	=	net costs to Land Transport NZ and approved organisations (where there is no service provider or non-government contribution)
	=	net service provider costs plus net costs to Land Transport NZ and approved organisations (where there is a service provider).

Note: Where an external service provider is involved, the net costs to government include the 'funding gap' that is paid by local and central government to the service provider so that the service is financially viable to the service provider.

BCR_N applies equally to TDM projects, transport services and road infrastructure projects. It indicates whether it is in the national interest to do the project from an economic efficiency perspective.

2.9 Benefit cost ratios, continued

Government benefit cost ratio

Land Transport NZ also uses a government benefit cost ratio (BCR_G), which indicates the monetised benefits obtained for the government expenditure (value for money from a central and local government perspective).

BCR_G is defined as:

$$BCR_G = \frac{\text{present value of national economic benefits}}{\text{present value of government costs}}$$

where:

national economic benefits	=	net direct and indirect benefits and disbenefits to all affected transport users plus all other monetised impacts.
government costs	=	net costs to Land Transport NZ and approved organisations.

Note: Where an external service provider is involved, the net costs to government include the 'funding gap' that is paid by local and central government to the service provider so that the service is financially viable to the service provider.

BCR_G is equal to BCR_N where there is no service provider or non-government contribution.

BCR rounding

The BCR shall be rounded to one decimal place if the ratio is below 10 and to whole numbers if the ratio is above 10.

2.10 Incremental cost benefit analysis

Introduction

Where project alternatives and options are mutually exclusive (section 2.13), incremental cost benefit analysis of the alternatives and options shall be used to identify the optimal economic solution.

The incremental BCR indicates whether the incremental cost of higher-cost project alternatives and options is justified by the incremental benefits gained (all other factors being equal). Conversely, incremental analysis will identify whether a lower-cost alternative or option that realises proportionally more benefits is a more optimal solution.

Incremental BCR is defined as the incremental benefits per dollar of incremental cost.

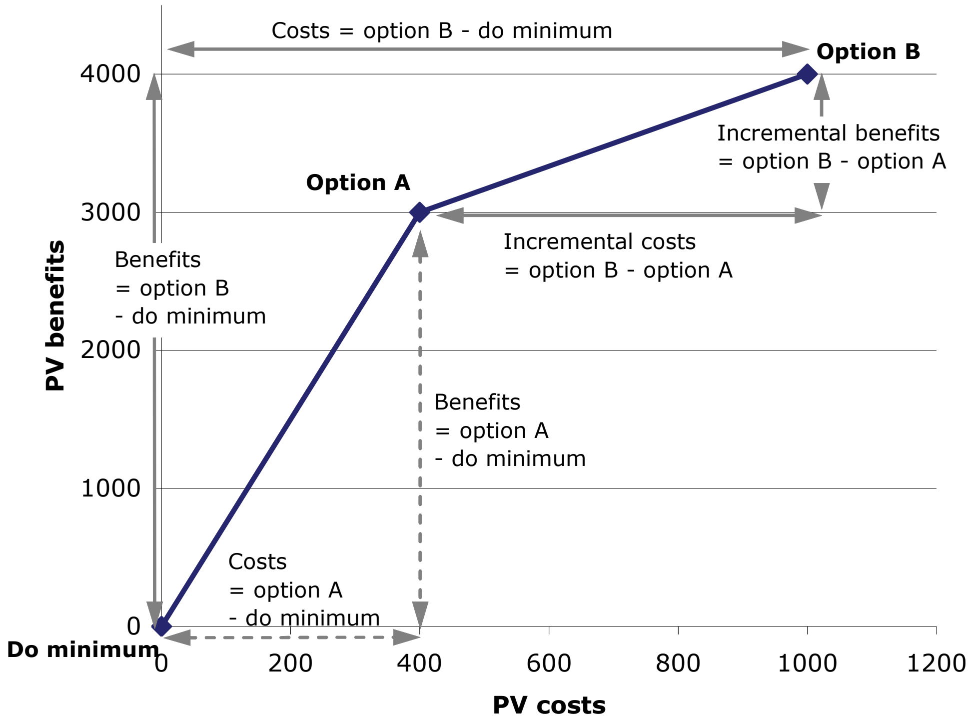
$$\text{Incremental BCR} = \frac{\text{Incremental benefits}}{\text{Incremental costs}}$$

2.10 Incremental cost benefit analysis, continued

Example

The concept of incremental cost benefit analysis is illustrated in the figure below, which considers two options – A and B.

The BCR for option B is 4.0 (4000/1000). Such a value would usually result in the project receiving a *High* rating for the economic efficiency criteria considered under Land Transport NZ's funding allocation process. The less-costly option A, with a BCR of 7.5 (3000/400), would receive the same *High* rating. However, incremental cost benefit analysis demonstrates that the incremental benefits gained by supporting option B ahead of option A represent only a small return on the additional cost, as the incremental BCR is 1.7 ((4000-3000)/(1000-400))



2.10 Incremental cost benefit analysis, continued

Procedure for calculating incremental BCR

The following procedure shall be used to calculate the incremental BCR of mutually exclusive options:

(a) Rank the options in order of increasing cost.

(b) Starting at the lowest-cost option, consider the next higher-cost option and calculate the incremental BCR of the PV of the incremental benefits to the PV of the incremental costs.

(c) If the incremental BCR is equal to or greater than the target incremental BCR, discard the lower-cost option and use the higher-cost option as the comparison basis with the next higher-cost option.

(d) If the incremental BCR is less than the target incremental BCR, discard the higher-cost option and use the lower-cost option as the basis for comparison with the next higher-cost option.

(e) Repeat the procedure in (b), (c) and (d) until all options have been analysed.

(f) Select the option with the highest cost which has an incremental BCR equal to or greater than the target incremental BCR.

Target incremental BCR

The method for choosing a target incremental BCR for testing project options is provided in appendix A12.4.

Sensitivity testing of incremental analysis

The results of the incremental BCR analysis should be sensitivity tested using a target incremental BCR that is **1.0 higher** than the chosen target incremental BCR. If this affects the choice of preferred project alternative or option, the results of this sensitivity test must be described and included in the project report. For example, if the target incremental ratio is 3.0, the choice of project alternative or option should also be tested by using a target incremental ratio of 4.0 and report how this affects the choice of option.

2.10 Incremental cost benefit analysis, continued

Example of incremental analysis

To analyse five mutually exclusive project options against a target incremental BCR of 3.0, first rank the options in order of increasing cost as follows:

Option	Benefits	Costs	BCR
A	110	15	7.3
B	140	30	4.7
C	260	45	5.8
D	345	65	5.3
E	420	100	4.2

Next, calculate the incremental BCR of each higher cost option, discarding those below the target incremental BCR as follows:

Base option for comparison	Next higher cost option	Calculation	Incremental BCR	Above/below the target incremental BCR
A	B	(140-110)/(30-15)	2.0	Below
A	C	(260-110)/(45-15)	5.0	Above
C	D	(345-260)/(65-45)	4.3	Above
D	E	(420-345)/(100-65)	2.1	Below

Finally select the option that has the highest cost *and* an incremental BCR greater than the target incremental BCR, which in this example is option D.

2.11 First-year rate of return

Introduction

First-year rate of return (FYRR) is used to indicate the best start date for projects. The correct theoretical basis for determining the optimal start time would be to calculate the incremental BCR of starting a project in year one compared to deferring the project to year two or a later year. However, this is a relatively complex calculation. For most projects, FYRR provides an equivalent basis for determining the best start date. The *Programme and funding manual* provides further guidance on the use of FYRR for project assessment.

First-year rate of return

For all projects, the FYRR shall be calculated for the preferred option.

FYRR, expressed as a percentage, is defined as the project benefits in the first full year following completion of construction divided by the project costs over the analysis period:

$$\text{FYRR} = \frac{\text{PV of the project benefits in first full year following completion} \times 100}{\text{PV of the project costs over the analysis period}}$$

2.12 Uncertainty and risk

Introduction

The forecasting of future costs and benefits always involves some degree of uncertainty, and in some situations the resulting measures of economic efficiency (the BCR and FYRR) may be particularly sensitive to assumptions or predictions inherent in the analysis.

Two types of uncertainty may occur in a transport project. Uncertainty about the:

(a) Size or extent of inputs to an analysis, such as the variation in construction, maintenance or operating costs; future traffic volumes, particularly due to model results, growth rates, and the assessment of diverted and induced traffic; travel speeds; road roughness; or accident reductions.

(b) Timing and scale of unpredictable events, either from natural causes (such as earthquakes, flooding and landslips) or from human-made causes (such as accidental damage and injury from vehicle collisions).

Assessing the sensitivity of evaluations to critical assumptions or estimates shall be undertaken using either a sensitivity analysis or risk analysis, or both, as appropriate.

The uncertainty described here is not directly comparable to assessing the uncertainty as part of Land Transport NZ's funding allocation process, which focuses on the confidence in the proposed project (or package) delivering the desired outcomes.

Sensitivity analysis

Sensitivity analysis involves defining a range of values for an uncertain variable in evaluating and assessing the effects on the economic evaluation of the assumptions or estimates within the defined range. This will highlight those variables for which a change in the input value has a significant effect on the economic evaluation, particularly the BCR and FYRR.

Risk analysis

Risk analysis is a more detailed type of sensitivity analysis involving describing the probability distributions of the input variables and those of the resulting estimates of benefits and costs. For a risk analysis to be possible, both the costs arising from each of the possible outcomes and their probability of occurrence have to be estimated.

The purpose of a risk analysis is to develop ways of minimising, mitigating and managing uncertainties.

2.12 Uncertainty and risk, continued

Choosing the appropriate analysis

Sensitivity analysis - for most projects the completion of a sensitivity analysis will be considered an adequate assessment of uncertainty.

Risk assessment must be undertaken for all projects with any of the following characteristics:

- the principal objective of the project is reduction or elimination of an unpredictable event (eg, a landslip or accident)
- there is a significant element of uncertainty
- the project capital value exceeds $4 million.

Land Transport NZ's *Programme and funding manual* provides addition guidance on risk analysis.

Methods for sensitivity and risk analyses

Guidance on completing a sensitivity analysis for road projects is given in section 3.8 of this volume. Sensitivity analysis for other types of project is described in volume 2.

Appendix A13 outlines the methodology for a risk assessment of road projects. Chapter 12 of volume 2 describes how these risk assessment procedures can be applied to other types of project.

The general procedure for evaluating risk by an analysis of probabilities and expected values comprises the following steps:

1. Identify the uncertain elements in the project and the chain of consequences for any unpredictable events.
2. Determine the benefits or disbenefits to transport users and the costs to the project for each possible outcome.
3. Identify an annual probability of occurrence and the period of years over which this probability applies for each uncertain element.
4. Compute the expected values of benefits and costs for the uncertain elements in each year as the product of the costs and the annual probability of occurrence. Include these in the project benefit and cost streams when discounting the cash flows.

A numerical-simulation approach may be required in cases where the number and interaction of uncertain variables makes an analytical approach impractical.

2.13 Alternatives and options

Need to consider alternatives and options

Early and full consideration must be given to alternatives and options (sections 20(3)(d) and 68(2)(b)(ii) of the LTMA 2003).

Alternatives are different means of achieving the same objective as the proposal, either totally or partially replacing the proposal. For example, TDM programmes are generally alternatives to the provision of road capacity.

Options are variations on the proposal, including scale and scope of components.

It is common for economic evaluations to concentrate on one preferred project option. Narrowing the scope of the analyses too early can cause serious errors, such as:

- neglecting options that differ in type or scale, eg, a road realignment that may eliminate a bridge renewal
- neglecting significant externalities, eg, the impacts of change in traffic flow upon adjoining properties
- inconsistencies with wider strategic policies and plans, eg, the impacts of improvements to a major urban arterial on downtown congestion.

All realistic project options shall be evaluated to identify the optimal economic solution. Rigorous consideration of alternatives and options is also a key component of Land Transport NZ's funding allocation process.

Mutually exclusive alternatives and options

Mutually exclusive alternatives and options (and package options) occur when acceptance of one alternative or option precludes the acceptance of others, eg, when a new road is proposed and there is a choice between two different alignments. The choice of one alignment obviously precludes the choice of the other alignment and therefore the two options are mutually exclusive.

Mutually exclusive options shall be evaluated in accordance with the incremental cost benefit analysis procedure in section 2.10.

Independent stages

Project stages shall be treated as independent projects if the different stages could be executed separately, and if their benefits are independent of other projects or stages.

Features to mitigate external impacts

Where alternatives or options include features to mitigate or otherwise address external impacts or concerns and the features significantly increase the cost of the options, the options with the features must be compared with the project option without these features. This analysis shall be undertaken irrespective of whether the features are independent of the project or mutually exclusive.

2.14 Packages

Introduction

Land Transport NZ seeks to encourage, where appropriate, approved organisations to develop packages of interrelated and complementary activities, either individually or in association with other approved organisations.

Packages are by definition multiple projects, which seek to progress an integrated approach to transport. Packages are intended to realise the synergy between complementary projects.

Packages may involve different activities, organisations and time periods. Packages should be:

- clearly related to specific transport issues and outcomes that emerge from the NZTS as expressed through the relevant regional land transport strategies, land transport programmes and long-term council community plans
- optimised to make the most efficient and effective use of resources.

The extent to which particular packages, and where appropriate components within such packages, are optimised to make the most efficient and effective use of resources, will be determined using the applicable project-evaluation procedures in this manual.

2.14 Packages, continued

Types of packages

In general, packages will fall into one of the following three categories:

1. **Packages for single agency with multiple activities.**

   An example of such a package would be the development of integrated urban traffic-control systems and complementary pedestrian and public transport priority measures.

2. **Packages for multiple agencies with multiple activities.**

   An example of such a package would be where a major state highway improvement is to be combined with traffic calming on local roads to improve the safety of the adjacent local road network. It is quite possible that when considered individually, neither project represents an efficient use of resources. Travel time and capacity issues may reduce the benefits of the traffic calming when considered as an isolated project. Similarly, main road traffic volumes may not be sufficient to warrant the highway upgrading as an isolated project. However, the combined project will benefit from the complementary nature of the two activities.

3. **Packages for multiple agencies with a single activity.**

   An example of such a package would be a proposal to seal a currently unsealed tourist route that passes through two local authorities. Such a proposal would be submitted as a package by the two approved organisations as a multiparty project. There are benefits to existing traffic in sealing each section of the route. However, to realise all the potential benefits, the entire route needs to be sealed. Therefore, separate analyses shall be undertaken for each section of the route and of the route as a whole. In doing so, the evaluation should highlight the efficiencies of a package approach.

Land Transport NZ's *Programme and funding manual* provides further examples of the different types of packages.

Evaluation of packages

Chapter 3 of this volume describes the procedures for evaluating packages comprised of road projects only, while chapter 3 of volume 2 describes the evaluation of packages comprised either of TDM strategies only or a combination of TDM strategies and road projects.

2.15 Transport models

Validation of transport models

When transportation models are used to generate demand forecasts and assign traffic to transportation networks, documentation should be provided to demonstrate the models have been correctly specified and produce realistic results. The documentation is listed in the series of checklists in worksheet 8.3 and these should be completed for each analysis time period.

The aspects of the models covered by the validation checks are as follows:

- Project model specification – including model type and parameters, data sources, trip matrices, assignment methodology and forecasting checks.
- A base-year assignment validation – comprising checks on link and screen-line flows, intersection flows, journey times and assignment convergence.
- Strategic demand model checks – incorporating validation of the models and techniques used to produce trip matrices.

Model reviewers may also use these checklists to confirm that appropriate documentation has been provided for review purposes.

Checks on output from traffic models

All project benefits calculated using a traffic or transportation model shall be checked to show the results are reasonable. The checks shall be done and reported at two levels – coarse checks and detailed checks.

Coarse checks

The objective of these is to check if the travel time benefits calculated are of the right order of magnitude. Travel time savings per vehicle shall be calculated for both the first year of benefits and a future year by dividing the daily travel time savings by the AADT of traffic traversing the project (worksheet 8.1).

Detailed checks

The objective of these is to ensure the travel times on individual road sections, through critical intersections and for selected journeys through the network, are reasonable. This analysis shall be undertaken for the first year of benefits and for a future year, and for both peak and off-peak periods if appropriate (worksheets 8.2).

These checks shall cover:

- road section speeds for both the do minimum and the project options
- peak-period delays and volumes at critical intersections for both the do minimum and the project options. Delays shall be based on the intersection approach which incurs the greatest delay
- travel times for both the do minimum and the project options for journeys which review the major travel time benefits, based on the travel time savings per vehicle for each journey route
- a comparison of the total travel time savings for journeys which receive the major travel time benefits and the total travel time savings predicted by the traffic model, in the first year of benefits and a future year.

2.15 Transport models, continued

Evaluating congested networks and induced traffic effects

Guidelines are provided in appendix A11 for modelling situations where very high levels of congestion are anticipated over the economic life of the scheme. Professional judgement should be used to determine the appropriate procedures to adopt. In cases where there are excessive or unrealistic levels of congestion in the do minimum network, a number of techniques may be used to generate a realistic and stable representation of the do minimum context. These commonly involve upgrading the capacity of the do minimum network or using some form of growth constraint on the trip matrix, such as matrix capping.

The matrix derived from this process remains the same in both the do minimum and project option, and is then used in the standard fixed trip matrix (FTM) evaluation procedure. Appendix A11 provides details of growth constraint techniques.

In some rare situations, significant levels of congestion may be expected in the project option across important parts of the network (spatially) and affecting a substantial proportion of the economic life of the project (temporally). The resulting induced travel may affect option benefits as well as the choice of roading option in a corridor. Where this is the case, the evaluation should incorporate an analysis of induced traffic effects.

If the expected effects will be sufficiently similar in each option (so that the relative economic performance of the options would not be affected significantly), it may be feasible to choose between options without a separate analysis of induced travel effects.

If significant induced traffic variations between options are not expected, or only a single preferred option is to be evaluated, advice should be sought from Land Transport NZ as to whether an analysis of induced travel effects should be completed. Appendix A11 contains procedures for evaluating induced traffic effects.

2.16 Other inputs to funding allocation process

Introduction

As noted in chapter 1 economic efficiency is only one of three assessment factors considered in Land Transport NZ's funding allocation process. This section provides some advice on the New Zealand Transport Strategy objectives to minimise double counting of benefits.

Economic development

Impacts to be considered should relate to enhancement of the economic wellbeing of New Zealanders – both the level of wellbeing and economic growth, including the potential for future growth. Impacts include:

- wider economic impacts, eg, facilitating transport
- impacts on land use
- travel time between economic centres
- congestion
- travel time reliability
- effect on freight
- energy efficiency.

In a limited number of circumstances, transport projects may have benefits to the economy over and above those included in the economic efficiency calculation.

Such benefits might result from:

- increased competition in imperfect markets, either for final products or factors of production (particularly labour and land)
- economies of scale in production leading to reductions in production costs.

Public transport improvements are likely to impact most on labour markets and land use activities.

2.16 Other inputs to funding allocation process, continued

Safety and personal security

Road-safety projects, some modifications to the road network and projects that reduce vehicle travel can contribute significantly to road-safety improvements. Passenger transport, cycling and walking improvements should specifically address safety and personal security issues, as well as effects on vulnerable users.

Accessibility and mobility

Accessibility for personal activities refers to the ability to reach desired goods, services and activities. For goods movement, accessibility can be defined as the ability to reach suppliers or buyers of products.

Mobility refers to the ease of travel. Mobility improvements can result in additional travel that would not otherwise occur, particularly by people who are transport disadvantaged. However, mobility is not the only means of improving accessibility.

TDM programmes can significantly improve access and mobility by increasing transport availability options and coordinating travel alternatives, eg, improved transport interchange.

Key determinants of accessibility include:

- the performance of the transport system – for a given land-use pattern, quicker, more reliable and/or lower-cost transport alternatives provide greater accessibility
- land-use patterns, including the density and mix of development – for a given level of transport performance, a more dense arrangement of land uses means greater accessibility because more activities can be reached within a given distance/time (the mix of land uses also influences accessibility).

Various measures of accessibility are:

- the number of jobs (or other opportunities accessible within X minutes of the average person in a region)
- number of residents accessible within X minutes of a typical employment site.

2.16 Other inputs to funding allocation process, continued

Accessibility and mobility, continued

Accessibility can also be distinguished by travel mode, income or other factors. Potential benefits of improved accessibility include:

- As a goal in itself. Providing individual or community accessibility to desired activities is often a fundamental objective for the transportation system.
- Greater economic activity. Businesses benefit from easier access to suppliers, a larger labour pool and expanded consumer markets. These factors can reduce transport costs both for business-related passenger travel and the movement of goods. Access to larger worker numbers, consumers and suppliers also provides greater choice and allows greater specialisation, thus increasing business efficiencies.
- Improved land-use patterns. Interaction between accessibility and land use means the relationship between transport improvements and accessibility gains is complicated. For example, the construction of a new road immediately improves accessibility and may lead to significant land development in its proximity. Eventually, the traffic generated by new developments can cause significant congestion, reducing the original accessibility benefits provided by the road.

While making the transport system more efficient, road tolling and other price-based TDM strategies may have a negative impact on mobility.

Public health

Improvements to public health can occur through increased physical activity and fitness, and through reducing exposure to pollutants or injury-causing activities.

Walking and cycling can have significant health benefits through increased exercise levels. However, this could be offset by an increased exposure to pollutants if the activity involves sharing road space.

Environmental sustainability

Environmental sustainability can be defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Projects that contribute directly to environmental sustainability are those that reduce noise and other pollutants, eg, measures that manage or reduce vehicle use. Evaluation of environmental effects (monetised and non-monetised) is described in appendix A8 and A9.

2.16 Other inputs to funding allocation process, continued

Sustainability of project performance	Sustainability of project performance describes how project benefits are maintained over time. Some projects have immediate impacts, while others may take years to have significant effects. In particular, the effects of TDM projects tend to change over time. In general, programmes that incorporate financial incentives, improve transport choice or involve land use management may become more effective over time as consumers incorporate them into long-term decisions. Conversely, the effects of travel behaviour-change programmes, which appeal to people's good intentions, tend to decline over time as promoters and participants lose interest.
Integration	Proposals should endeavour to improve the arrangement of land use, walking and cycling networks, public transport, and local and strategic roads.

2.17 References

References

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