Overview of project appraisal for land transport

Bureau of Infrastructure, Transport and Regional Economics

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Introduction

A project appraisal process helps a government make good choices in terms of its goals. It starts with a clear understanding of the role of the project in addressing the key problems preventing achievement of goals specified in a broader integrated transport and land use plan. Projects should ideally be targeted at addressing the most important problems identified in broader transport plans. Project proponents should have a clear understanding of what their project aims to achieve.

Good project appraisal also requires the full exploration of reform and investment options to address the key problems to ensure that the project solution provides the best return for society's scarce resources.

Cost–benefit analysis (CBA) is the primary appraisal tool at the options assessment and project prioritisation stages of the appraisal process. It is a rigorous, transparent, quantitative method that measures the degree to which individual projects generate net benefits (benefits minus costs) across Australia, and allows comparison and ranking of options and projects.

CBA sits within a broader planning and appraisal framework designed to ensure that projects:

- Flow from good strategic-level planning and assessment
- Are closely aligned with high-level national, state and territory goals
- Are aimed at addressing priority problems that are preventing goals from being achieved, and
- Adopt the best solution, based on a sound assessment of a wide range of potential options for solving the identified problems.

The best practice transport planning and appraisal framework in Australia is defined jointly by the *National guidelines for transport system management in Australia* (NGTSM 2006) and Infrastructure Australia's *Better infrastructure decision-making* (IA 2013a). The NGTSM is currently being updated and revised to:

- Align with Infrastructure Australia's framework and guidelines
- Incorporate the complementary Austroads Guide to Project Evaluation and Guide to Road Transport Planning
- Provide guidance on important recent developments in tools and techniques that have significant implications for future approaches to transport planning and project appraisal. These include: wider economic benefits (WEBs), productivity metrics, real options analysis, use of computable general equilibrium models, and CBA of active travel, climate change adaptation, maintenance and non-infrastructure initiatives. Non-infrastructure initiatives covers regulatory changes, intelligent transport system projects, and travel behaviour change programs
- be published as website.

The NGTSM covers all land transport modes. It sets out a comprehensive framework for integrated transport and land use planning and analytical approaches to transport project appraisal (mostly CBA). The NGTSM update will build on the non-CBA aspects of transport appraisal contained in the current guidelines, particularly the upfront integrated transport and land use aspects of the framework.

This paper outlines first the broader appraisal process in which CBA sits, and second, CBA itself with the recent developments of wider economic benefits and productivity metrics.

A draft of the paper was released for public comment on 5 September 2014. The paper has since been revised after considering the submissions received. Some of the suggestions in the submissions have been implemented in the revised paper, whereas others would require wider consultation with practitioners in government and industry before they could be adopted. The submissions will be further considered by the committee charged with revising the NGTSM.

The appraisal process

The flowchart in figure 1 shows the project appraisal framework in the NGTSM held up as best practice. It does not purport to represent what occurs in practice. The strategic planning process involves setting high-level goals to guide the transport system as a whole, followed by the development of supporting objectives and targets at various planning levels: city and region, corridor and area, route and link. The first box in figure 1 represents the planning stages without the detail presented elsewhere in the NGTSM (2006, vol. 2). These planning stages would be carried out successively at multiple levels, first for the system as a whole, then for particular corridors or areas, and finally at the route or link level.

The stated goals, objectives and targets are used to identify 'problems' where current or projected future performance fails to meet objectives or targets (NGTSM 2006, IA 2013a, Austroads 2009). The problem stage is divided into:

- Identification (constraints on achievement of stated goals)
- Assessment (data-rich evidence that it is a priority to address the problem), and
- Analysis (extent of the problem and root causes).

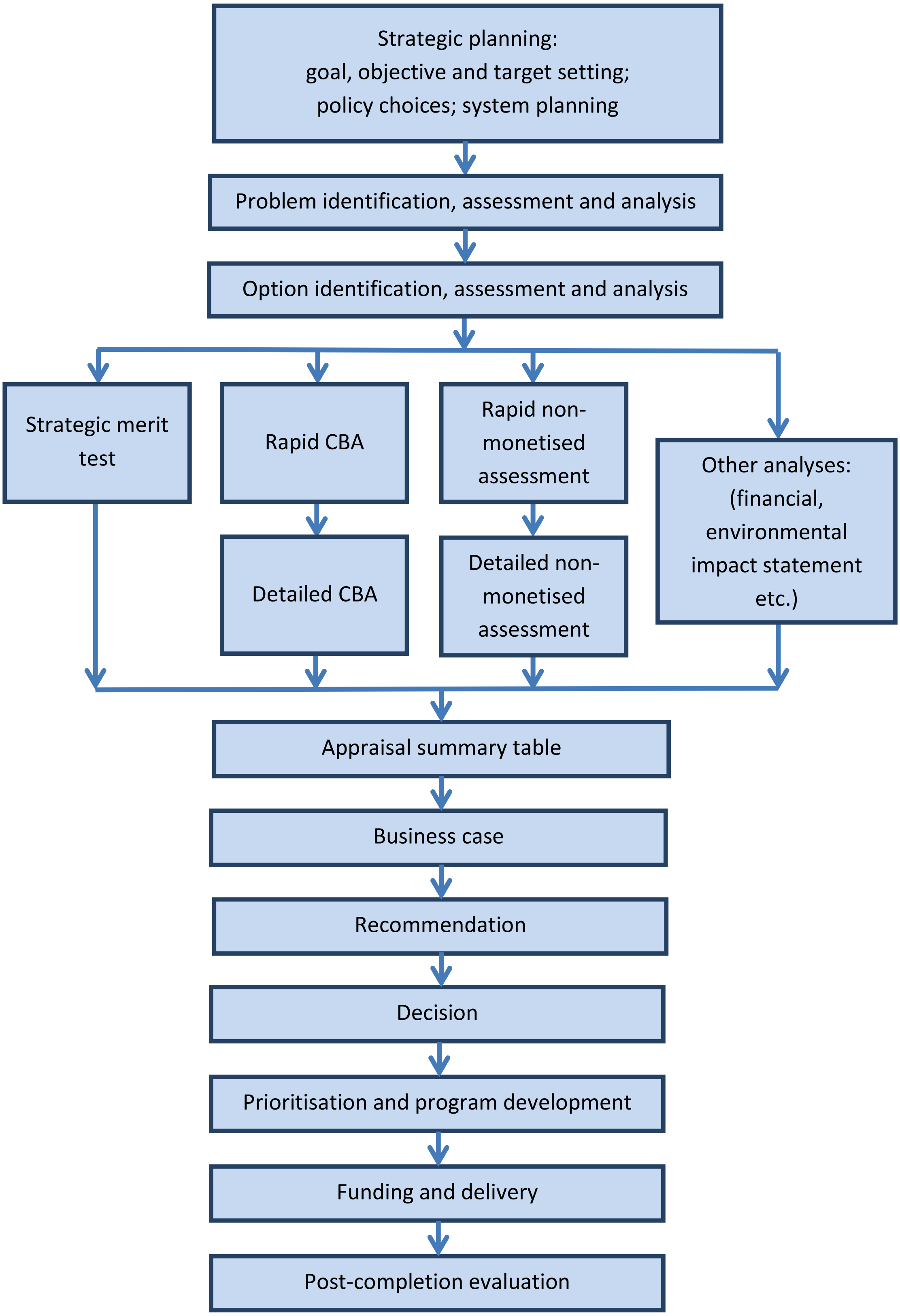
Useful tools for the problem stage include scenario assessment and deficiency analysis (identifying instances where the system falls short of benchmarks and targets).

The next step is 'option generation' — development of a full range of possible options to solve the problem. As well as new infrastructure and expansions to existing infrastructure, the range of options should include non-infrastructure solutions, which can be grouped into regulatory reform, governance reform and better use of existing infrastructure (IA 2013a).

The 'options assessment' step gradually narrows down the wide list of options to a short list, and then to a preferred option. This occurs through assessments applied at progressively increasing levels of detail and accuracy. The key appraisal tools are: the Strategic Merit Test (SMT), rapid CBA and detailed CBA. The process can be iterative with new options and initiatives generated along the way. This step should maintain a clear line of sight to the goals and problems identified in the earlier steps of the transport appraisal.

Options that clearly fail the SMT and/or rapid CBA tests can be rejected early. The next stage involves detailed assessment of strategic merit and economic worth. Where multiple options for the same project cannot be eliminated easily, they would be subjected to detailed appraisal.

Figure 1. Appraisal methodology flow chart



Source: Adapted from NGTSM (2006, vol. 3, p. 11)

The SMT asks questions about barriers to implementing the initiative and its contribution to objectives, policies and strategies. Many projects and options will be ruled out because of technical, environmental, heritage or legal issues or overwhelming community opposition. Proposals arising out of the planning processes will reflect jurisdictional objectives, policies and strategies and so should readily pass the strategic alignment part of the SMT. The SMT is particularly useful for screening proposals that originate from outside the planning processes (NGTSM 2006, vol. 1).

NGTSM (2006) distinguishes between rapid CBA and detailed CBA. Rapid CBA is a cost-effective way of gauging whether a proposal or option is likely to pass a detailed appraisal. It involves indicative estimation of the main benefits and costs without expending the resources necessary to achieve a high level of accuracy. NGTSM (2006, vol. 3) states that, based on the experience of Australian jurisdictions, the expected margin of error for investment cost estimates in rapid CBAs is ±40%, compared with ±10% for detailed CBAs. For small projects, the SMT and rapid CBA may suffice without a detailed CBA.

The process in figure 1 is iterative and the scope and timing of options and initiatives may have to be adjusted several times in order to develop a final program that is affordable within available funding (NGTSM 2006, vol. 2, p. 66). Throughout the problem, option and rapid appraisal phases, initiatives should be progressively scoped and defined. A clear scope and definition is essential for conducting a good CBA and can help address the problems of unrealistic cost and demand forecasts referred to later in the paper.

CBA at the detailed level plays a central role in the appraisal process, but it does not tell the whole story. Other activities in the appraisal process include stakeholder consultation, preliminary engineering design, financial assessment (if the initiative generates revenue), risk assessment, investigation of legal issues, preparation of an Environmental Impact Statement, development of funding options, socio-economic analysis including distributional and equity impacts, assessment of overall impact on the economy, and consideration of land use implications (NGTSM 2006, vol. 3).

In determining the overall merit of a project, considerations should not be limited to the monetised benefits and costs captured in the CBA. There may be important non-monetised benefits and costs. A good CBA will identify and describe non-monetised benefits and costs, where possible quantifying them in physical units. It will also describe how the community will be affected and the likelihood that the full impact will be realised.

It is important to bring together the various strands of assessment into a summary form to present the whole picture. The NGTSM (2006) recommends use of the Appraisal Summary Table (AST) technique to bring together all the relevant information to assist decision making. Initially developed by the UK Department for Transport, the AST has been adopted by some Australian jurisdictions. The AST presents information on all impacts, monetised and non-monetised, in a single table with subjective ratings for the size and direction of each impact and the level of confidence. The NGTSM (2006) proposes a qualitative non-monetised rating system that describes impacts as being either positive or negative, and whether the scale of the impact is neutral, small, moderate or large. The impacts can be grouped in triple-bottom-line format — economic, social and environmental. The main CBA results are also presented. Decision makers can make a judgement based on the information presented about the overall merit of a project. Table 1 presents an example AST.[1]

The AST is a form of 'multi-criteria analysis' (MCA), a general term for techniques that bring together information about the impacts of a project assessed under different criteria. Importantly, the AST does not try to produce an overall single score as an indicator of a project's overall merit. The single score approach, which involves attaching weights to objectives, scoring each impact against each objective and calculating the weighted average score, is highly subjective. It can be manipulated to produce virtually any desired result. So the revised NGTSM strongly recommends against use of the single score MCA approach, preferring instead, use of the AST (including CBA results) or similar tools.[2]

The results of the SMT, CBA, AST and other assessments are all brought together in a single document called the 'business case', which presents all the necessary information to make a recommendation. The remaining steps shown in figure 1 are decision making, prioritisation and program development, delivery and post-completion evaluation.

Most of the activities in figure 1 would be carried out by the government agency responsible for planning, funding and delivering initiatives. This agency may or may not be the proponent of a particular initiative. The proponent is usually responsible for undertaking the CBA and the activities in the 'other analyses' box of figure 1.

For the appraisal process to work well, the various activities need to be undertaken in an unbiased manner, not favouring any particular solution. It defeats the purpose if the outcome is predetermined. Some of the elements in figure 1 involve considerable subjectivity, in particular, the SMT, AST and non-monetised assessments. Although the CBA methodology is rigorous in principle, there are many ways to skew results if desired. Institutional and governance arrangements ought to be put in place to reduce potential bias, for example, ensuring that the people assessing options and preparing the SMT, AST, non-monetised assessments and business cases are not the proponents of particular projects. Engagement of independent reviewers and public release of documents, data and modelling can also protect against bias.

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[1] The row headings in table 1 are illustrative only. Jurisdictions are free to specify their own headings. The current UK version of the Appraisal Summary Table has four first-level row headings — economy, environmental, social and public accounts. Although the table features a column for net present values of individual impacts, it has no place in which to insert aggregate CBA results, as in the last row of table 1. Inclusion of aggregate CBA results in appraisal summary tables is essential. See https://www.gov.uk/government/publications/webtag-appraisal-tables

[2] For critical discussions of quantitative MCA, see Dobes and Bennett 2009 and Ergas 2009.

Table 1 Appraisal summary table

A23 COULSDON		1996 SCHEME — 1.7KM D2 BYPASS	COST £39.9m	
Problems		High flows (31,000 vpd) on A23 through Coulsdon town centre cause delays, diversion onto local roads, high accident rates and disruption of bus and coach movements. Associated pollution in the town centre.		
Other options		Traffic management was considered in very early assessments. Transport 2000 suggested a smaller scale scheme at the Public Inquiry. Option of single carriageway has been considered, but would offer little cost saving		
CRITERIA	SUB-CRITERIA	QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
Environmental impact	Noise	Benefits from removal of traffic from Coulsdon town centre.	No. properties experiencing (w/s): • Increase in noise 48 • Decrease in noise 179	net 131 properties win with scheme
	CO_2 tonnes added	–	–	0 – 2000
	Local air quality	Air quality improves as traffic removed from Coulsdon town centre.	No. properties experiencing: • improved air quality 129 • worse air quality 3	-130PM_{10} -772 NO_2
	Landscape	Line of route is in urban setting and closely parallels the existing railway line.	–	Neutral
	Biodiversity	Adversely affects important chalk grassland habitat forming part of site of local conservation importance.	–	Moderate -ve
	Heritage	Slight impact on one listed building and archaeological area of potential, but mitigation agreed.	–	Neutral
	Water	There are particular concerns with this scheme regarding the impact of contaminated land on the underlying aquifer, which is used for public water supply. Further investigations will be required to determine whether or not an acceptable solution can be identified.	–	Large -ve
Safety	–	Accident rates in Coulsdon town centre are currently above national average.	Accidents Deaths Serious Slight 760 8 184 590	PVB £8.1m 36% of PVC
Economy	Journey times & VOCs	Town centre flows fall to 20% of pre-opening levels, but total traffic (on both old/new routes) would increase by over 20%.	peak inter-peak N/A N/A	PVB £154m 690% of PVC
	Cost	–	–	PVC £22.4m
	Reliability	Currently highly congested and forecast to get worse.	Route stress Before: 130% — After: 48%	Moderate Mod rel. to PVC
	Regeneration	–	Serves regeneration priority area?	No
Accessibility	Public transport	Increased reliability of public transport journey times in Coulsdon town centre.	–	Moderate +ve
	Severance	Over 7 000 people experience substantial relief from community severance.	–	Large +ve
	Pedestrians & others	others. Facilities for pedestrians would be improved in town centre.	–	Large +ve
Integration		Croydon Unitary Development Plan supports use of strategic network by longer distance traffic and improving conditions for cyclists and pedestrians.	–	+ ve
CBA			PVB £160m PVC £22m NPV £140m BCR 7.2	

Source: NGTSM (2006, vol. 3, p. 46). Originally from UK Department for Transport

CBAs and business cases are often not made public. The recent Productivity Commission report on public infrastructure argued that making CBAs public, with clearly documented assumptions, for both projects that have been selected and projects that have been rejected, would greatly improve the transparency of decision making. Such transparency

- Strengthens the incentives for decision makers to focus on the overall net benefits of projects. It draws attention to projects that, while appealing to particular groups or regions, are poor value for money for the community overall
- Allows the assumptions and estimates (such as construction costs and patronage forecasts) to be critiqued and debated, flaws exposed, the reliability of the appraisal to be assessed, and ultimately the quality of analysis to be improved, and
- Provides additional information to private entities bidding for delivery of projects, helping them undertake their own analysis and avoiding duplication of analyses.

The Commission was not convinced that there are valid commercial-in-confidence reasons to withhold release of full CBAs (PC 2014, pp. 92-3 and 104-6). These arguments for transparency may apply to other elements of the appraisal process as well as the CBAs.

In the revised NGTSM, new material will be added on actions to facilitate and formalise post-completion evaluation by establishing a consistent approach to monitoring and evaluating the success of investments. This is a component of what is now being termed ‘benefits realisation management’, ‘benefit management’ or ‘benefit realisation’. Some Australian jurisdictions have prepared benefit realisation guidelines, for example, NSW (2014). Prior to implementation of the investment project, benefit management includes identifying the intended outcomes and planning the necessary arrangements to assess progress such as targets, indicators and data requirements. After implementation, the project’s performance is monitored, corrective actions taken where there are deviations from the plan, and reports made in accordance with the plan. It should be noted that benefits realisation or management planning is broader than post-completion evaluation as it encompasses planning actions necessary for the full realisation of project benefits such as undertaking complementary projects or altering land-use plans. These actions are frequently outside the direct control of the project proponent, so the benefits realisation plan has to address how the responsible parties can be influenced to ensure their delivery is aligned.

Another form of post-completion evaluation is to undertake expost CBAs some years after implementation to assess the strength of the project’s economic justification with hindsight and to learn lessons to improve CBAs in the future. Benefit management plans should support conduct of expost CBAs by ensuring the necessary information is readily available.

Cost–benefit analysis

CBA aims to identify and express in monetary terms, all the gains and losses (benefits and costs) created by an initiative to all members of society, and to combine the gains and losses into a single monetary measure. A positive result means the project is expected to generate net benefits for society (benefits minus costs) and therefore increases the efficiency of resource use — in other words, Australia, as a whole, is better off. It is a well-established methodology widely employed by government departments and consultants in a range of areas around the world. It not only permits comparisons between projects for different transport modes, but also between the transport sector and other sectors of the economy. It can be applied to non-infrastructure solutions such as introduction of new technology, regulatory changes and pricing solutions. While analysts have considerable leeway in making assumptions, the rules about which benefits and costs to include in CBAs and ways of valuing them are, for the most part, well established. If the rules are correctly implemented, a CBA will comprehensively cover the benefits and costs without double counting (NGTSM 2006, vol. 3, p. 52).

A CBA is always a comparison between two alternative states of the world, a 'base case' in which the project does not proceed, and a 'project case' in which it does. The appraisal is undertaken over a number of years related to lives of the assets created, for example, usually 30 years for new roads and 50 years for new railway lines, plus the construction period.

The main cost is usually the investment cost, the capital cost incurred at the start of the project to create the assets.[3] After implementation, there will be operating and maintenance costs. Capital, operating and maintenance costs will occur in both the base case and project case, with the *incremental* changes between the two used in the CBA calculations.

Benefits from transport projects are strongly related to infrastructure utilisation levels. Demand forecasts therefore play a critical role. Benefits can be categorised by type or by recipient. By type, for transport projects, travel time savings, are usually the largest category, followed by savings in vehicle operating costs, crash costs and environmental externalities. Other benefit types include improvements in reliability and passenger comfort, and savings in infrastructure operating or maintenance costs. Categorised by recipient, benefits accruing to users tend to be the largest category, followed by producers, governments and others.

Benefits and costs are valued based on peoples' willingness-to-pay. For benefit and cost types that are traded in markets, willingness-to-pay can be estimated from prices. For non-marketed benefits and costs, willingness-to-pay can be inferred from consumers' behaviour or statistical analysis of survey data.

Project impacts are most accurately estimated as close to their sources as possible. Savings in time, reliability and vehicle operating costs are estimated as such, not further downstream when they are translated into changes in employment, production, industry development, incomes, tax receipts, land values and so on.

Part 4 of the Austroads Guide to Road Project Evaluation (to be incorporated into the new NGTSM) contains recommended parameter values for road projects such as fuel costs, values of travel time savings, unit crash costs and environmental externalities. Austroads has been updating these at two-year intervals. The revised NGTSM will publish and keep up to date a separate parameters volume containing all the road parameters from the former Austroads Guide together with parameters for other modes (public transport, active travel, freight rail). Use of recommended parameters values promotes consistency and comparability between CBAs. NGTSM (2006, vol. 3) recommended that project proponents be allowed to use different parameters provided they detail their reasons, justify their preferred values and do a sensitivity test using the recommended values.

[3] Non-infrastructure initiatives are exceptions. They can involve only small initial investment costs or investment costs spread over time as a change is rolled out.

Benefits and costs are discounted to the present at a discount rate representing the fact that a dollar in the future is worth less than a dollar today. Infrastructure Australia asks for CBA results at a 7% discount rate in real terms, that is, adjusted to remove the effect of inflation, and sensitivity tests at 4% and 10% (IA 2013b). The Department of Infrastructure and Regional Development asks for CBA results at 4% and 7% in real terms. The 4% rate is intended to represent a level not far above the risk-free rate for the 'social opportunity cost of capital'. The appropriate risk premium for CBAs of public sector projects, as calculated by Quiggan (2005), is so small as to be practically negligible.[4] The 7% rate has long been the traditional discount rate used for transport projects in Australia and approaches the 8% rate recommended by Harrison (2010) for the social opportunity cost of capital based on the long-term before-all-tax real rate of return earned by private capital in Australia. Economists are unable to arrive at a united position on the choice of discount rate, so there can be no universally accepted 'correct' rate. Without elaborating further on a highly technical issue, the difference between Quiggin (2005) and Harrison (2010) arises from different views about the 'equity premium puzzle'. As an example of an entirely different approach, UK uses 3.5%, which is an estimate of the 'social time preference rate' (HM Treasury 2011). Each jurisdiction will specify its own preferred discount rate. Sensitivity testing is an appropriate way for addressing the uncertainty about the correct discount rate. Many projects will either pass or fail at both the Department's 4% and 7% discount rates.

The main bottom-line CBA results are net present values (NPVs) and benefit–cost ratios (BCRs). Results of NPV > 0 and BCR > 1 indicate that benefits exceed costs, and hence the project makes a positive contribution to economic efficiency. NPV should be used to select between mutually exclusive options for the same project. The BCR should be used to rank projects in the face of funding constraints that prevent implementation of all projects with a BCR above one. BCRs should be defined so that costs that come out the constrained funding pool, usually investment costs only, are placed in the denominator. Changes in operating and maintenance costs, which come out of future budgets, should be counted in the numerator.

How a project is financed will not affect a CBA except to the extent that pricing (road tolls, fares for public transport) affects quantities demanded and estimates of user and producer benefits, and there are revenue collection costs. NGTSM does not cover financial analysis and public–private partnerships. Private sector participation may be relevant to project prioritisation where injection of private sector funds allows projects that could not otherwise be afforded to be undertaken, provided those projects have BCRs above one. NGTSM (2006, vol. 3, p. 94) proposes a rigorous test to use in such cases.

4 Risk here refers only to 'systematic' or 'non-diversifiable' risk, that is, risk that is symmetrical around the mean ('pure' risk). For project-specific risk, systematic risk stems from project benefits being correlated with per capita consumption. As for pure risk that is not systematic, much of it is diversified away as individual consumers benefit in small amounts from a large number of public infrastructure projects, just as for a share investor with a diversified portfolio. Risk that is not symmetrical around the mean, that is, arising from optimism bias, should be addressed directly in project benefit and cost estimates, as discussed in the next section, not by raising the discount rate. It would be an unlikely coincidence if the discount was raised by the correct amount to offset the optimism bias for a given project. A higher discount rate would tend to under-compensate for optimism bias in the early years of a project's life over when the over-estimation of costs and under-estimation of benefits are most likely to become evident, and over-compensate in the later years when compounding of the high discount rate leads to a high discount factor.

Department of Infrastructure and Regional Development template

Tables 2 and 3 are from the Department of Infrastructure and Regional Development's Project Proposal Report template. They are designed to provide additional information on top of the CBA summary results to assist reviewers with checking the realism of benefit estimates and demand forecasts. From table 2, the Benefit Table, it can also be seen whether the percentage split of benefits is consistent with the project's stated objectives. For example, the greater part of benefits from a project aimed at reducing congestion would be expected to be time and vehicle operating cost savings, rather than safety or environmental benefits. The split of benefits between passengers and freight/business provides information on whether a project supports passenger- or productivity-related objectives. The information in table 3, the Traffic Use and Assumptions Table, provides a check on the assumed demand growth over time and the significance of diverted and generated demand.

Table 2 requests information on benefits for a single year. The choice of year 10 after project completion is somewhat arbitrary. By year 10, any assumed ramp-up period in the demand forecasts and changes that might affect demand following project completion would have finished. Dividing the benefit estimate for year 10 by the relevant physical quantity for the same year gives a weighted average of the unit cost assumptions used to calculate benefits. For example, dividing year 10 total time savings benefit by the total number of hours saved gives the weighted average of the unit value of time assumptions. Reviewers can check that the weighted average unit values appear reasonable.

Table 2 Department of Infrastructure and Regional Development benefit table

Benefit component		Present value of benefits in $m	Year 10 benefits in $m (10 years after construction completion)	Year 10 benefits: Percentage of total benefits	**Underlying Physical Quantity** eg. time savings in hours, total VKT, number of accidents/fatalities/injuries avoided
Travel time savings	Passenger	324.66	19.73	47.90	Time savings of 869,246 hours
	Freight and business	160.89	9.74	23.64	Time savings of 198,120 hours
	Total travel time savings	485.54	29.46	71.54	
Reduced vehicle operating costs	Passenger	101.39	6.15	14.94	Total vehicle km travelled is 182,541,608 vkm
	Freight and business	114.25	6.93	16.83	Total vehicle km travelled is 41,605,127 vkm
	Total user benefits	215.64	13.09	31.77	
Generated Travel Benefits	Passenger	5.71	0.40	0.96	Total vehicle kilometres travelled is 5,580,030 vkm. Time savings of 26,572 hours.
	Freight and business	3.70	0.25	0.62	Total vehicle kilometres travelled is 1,271,808 vkm. Time savings of 6,056 hours.
	Total road user benefits	9.41	0.65	1.58	
Accident reductions	*Total accident reduction benefits*	14.28	0.87	2.10	Reduction in accidents in year 10 is 0.14 fewer fatalities, 1.87 fewer injuries and 4.98 fewer PDOs
Environmental benefits	Reduced greenhouse emissions	-7.16	-0.43	-1.05	Net extra 18,099 tonnes of CO_2 equivalent emitted
	Reduced local pollution	-9.09	-0.55	-1.34	
	Reduced noise	-2.97	-0.18	-0.44	
	Total environmental benefits	-19.22	-1.17	-2.83	
Reduced maintenance costs	*Total reduced maintenance costs*	-4.29	-1.72	-4.16	Extra 49,000 square metres of pavement
Wider economic benefits	Agglomeration benefits	0.00	0.00	0.00	
	Other wider economic benefits	0.00	0.00	0.00	
	Total wider economic benefits	0.00	0.00	0.00	
Other benefits	*Total other benefits*	0.00	0.00	0.00	
TOTAL BENEFITS		701.36	41.19	100.00	

Table 3 Department of Infrastructure and Regional Development traffic and use assumptions table

		First year after project completion	10 years following project completion	30 years following project completion
Users in Base Case	Passenger	61,920	69,553	86,564
	Freight and business	13,810	15,853	20,380
Users diverted from other infrastructure	Passenger	1,684	1,892	2,355
	Freight and business	376	431	554
Generated trips	Passenger	972	2,184	2,718
	Freight and business	217	498	640

Risk and uncertainty

All benefits and costs that go into a CBA are forecasts of the future and so are subject to risk and uncertainty. Project appraisals have a reputation for 'optimism bias', which is a tendency to over-estimate benefits and under-estimate costs.[5]

Sensitivity analysis is a simple approach to exploring the level of risk in CBAs. More sophisticated approaches involve assigning probability distributions to risky or uncertain variables and using computer simulations (for example, Monte Carlo methods) to derive probability distributions for bottom-line CBA results. To the extent that these approaches give rise to a disciplined consideration of what can go wrong, optimism bias may be reduced.

The Productivity Commission noted that unrealistic cost and demand forecasts also arise due to strategic misrepresentation. Project proponents often have a personal stake in the project's proceeding and so have an incentive to make it appear better than it really is. Attention should therefore be given to the institutional and governance arrangements within which analyses are done (PC 2014, p. 102).

For transport infrastructure projects with an estimated cost in excess of $25 million being considered for Commonwealth funding, the Department of Infrastructure and Regional Development requires that proponents develop their investment cost estimates using a quantitative (probabilistic) risk analysis approach, and that these costs be reported at P50 and P90 levels. P50 and P90 are the project costs with sufficient contingency to respectively provide a 50% and 90% likelihood that these costs will not be exceeded. With half of the area of the probability distribution on either side, P50 is the median of the probability distribution.

Another approach that has been used to address risk in project costing is the deterministic approach. It involves applying a percentage contingency allowance to base estimates for either individual cost elements or to the aggregate project cost. Using the deterministic approach, the amount of the percentage contingency allowance would be quite small to approximate a P50 estimate, and relatively larger to approximate a P90 estimate (Evans and Peck 2008, p. 32).

5 See PC 2014, pp. 100-2 for a recent discussion.

Deterministic project costing may be appropriate for smaller projects and rapid CBAs, where the greater effort required to undertake a probabilistic assessment may not be warranted. However, to be useful, the technique requires access to reliable benchmark data, particularly at the whole of project level, in order to estimate the contingency allowance. Both the probabilistic and deterministic approaches require input from experienced practitioners

The CBA results used for decision making should be 'expected values', that is, the means of the probability distributions for the NPV and BCR. These can be obtained by ensuring that all the individual cost and benefit estimates going into the CBA are expected values. For investment costs, the P50 value or median will equal the mean or expected value if the probability distribution is symmetrical. If the distribution is reasonably symmetrical, the P50 value can be used as an approximation of the mean for the central scenario for a CBA. The P90 value could then be used as a sensitivity test to gauge the impact of investment costs being higher than expected. It is understood that some state treasuries use the P90 estimate for budget funding purposes on the grounds that, due to optimism bias, the P90 value may be closer to the expected value than the P50 value.

The real options approach

As already pointed out, option identification and assessment is a cornerstone of good project appraisal. Identifying and assessing options over the time dimension can be a powerful way to deal with downside risk (the risk of a bad outcome). The 'real options' approach involves consideration of options for waiting and staged flexibility. A 'real option' is a decision taken today that makes it possible for policy makers to take a particular action in the future. Real options are similar to financial options but are exercised over real assets rather than financial assets (PC 2012, pp. 12 and 97). Options are explored that involve adopting a 'wait and see' approach until a major uncertainty is resolved or lessened and the project is more clearly going to be successful.

A decision could be delayed until better information about the future is available, for example, deferring a decision to invest until it is known whether a new urban or industrial development, which will have a major impact on the project's demand forecasts, will occur. Note that keeping open the option to invest later can involve additional short-term costs (an 'option premium') such as purchase or reservation of land.

Options could be implemented that allow for flexible responses as new information emerges. For example

- for a small initial investment cost, the project could made 'shovel-ready' to proceed quickly if traffic growth increases
- being prepared to abandon a project prior to construction, or even during construction, if circumstances change or initial expectations do not materialise
- building a project with a smaller capacity initially but with preparations to facilitate expansion later, for example, through land acquisition or earth works or constructing stronger bridge pylons
- building lower-cost infrastructure with a shorter lifespan initially, deferring a decision to build more expensive long-lived infrastructure until demand has increased to a viable level.

Analytically, the decision criterion is to choose the option that maximises the expected value of the NPV obtained from a probabilistic assessment. To illustrate how it can be advantageous to delay a decision, say, if a decision to invest is made now, there is a probability of a bad outcome depending on an uncertain circumstance. If the decision is deferred until the uncertainty has been resolved, the possible bad outcome is eliminated from the expected NPV calculation. The gain from removing the possible bad outcome from the calculation could exceed the net loss of benefit from deferring the decision and any costs incurred to keep the option open.[6]

Real options approaches to infrastructure provision might not be very compatible with government budgetary and assessment processes. A decision to delay full implementation of a project might be seen as a failure on the government's part. Funds available in the short-term to implement a project in full, may be not available later if the project is initially implemented only in part.

The real options approach has attracted interest as a way to deal with climate change uncertainty (Dobes 2008, Linquiti and Vonortas 2012, PC 2012). In its recent infrastructure report, the Productivity Commission (2014, p. 9) endorses use of real options analysis 'where useful'. The revised NGTSM will deliver an expanded discussion of the topic.

A related issue is application of CBA to disaster mitigation and building resilient infrastructure, which is expected to gain greater prominence in the near future with the Productivity Commission's current inquiry into National Disaster Funding Arrangements. The principle of choosing the option that maximises the expected value of the NPV applies. Probabilities of disasters, for example flooding, can be estimated from past history, though modifications may be needed to account for climate change.

Projects that stimulate economic growth

Different approaches are required to forecast demand and estimate benefits to users of new or upgraded transport infrastructure, depending on whether the users are existing users of the infrastructure, diverted from other routes or modes, or generated by the project. Projects that are expected to stimulate economic growth in a region will derive a high proportion of their benefits from new or generated users. While the principles for estimating benefits from new demand generated by a project are straightforward, forecasting new demand and translating it into dollars of benefit in practice is difficult. There a serious risk that the new demand will not materialise and anticipated project benefits will not be realised. However, the number of potential projects that will generate large demand increases is likely to small because, in a mature economy, it can be difficult to identify projects that will open up new economic opportunities.

Where there is a new economic opportunity and it requires a new road or railway line, if it involves a single user, such as mine, that user should pay for the infrastructure, and the user would have the incentive to do so if benefits exceeded costs. There should not be any need for government investment. But where there are multiple potential users who cannot reasonably be expected to come to a cost sharing agreement to resolve the 'free-rider' problem, there may be a justifiable role for government. Demand forecasting in such cases could include making the same financial calculations as potential users of the new infrastructure to gauge whether the new project will lead to profitable investment opportunities.

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[6] Real options in financial markets are analysed using either the Black Scholes theorem or its discrete equivalent, the binomial lattice approach. It may be incorrect to apply models developed for financial options to infrastructure as the necessary assumptions are unlikely to hold.

Limitations of CBA and non-monetised benefits and costs

CBA provides information about the extent to which a project generates net benefits and therefore increases economic efficiency. The economic efficiency concept encompasses social and environmental impacts (for example, safety and externalities). To the extent such impacts can be monetised, they can be directly accounted for in CBAs. Some impacts, such as social cohesion, urban amenity and biodiversity cannot easily be monetised, and must be described in non-monetised terms. The non-monetised impacts can be considered subjectively alongside the monetised impacts. The Appraisal Summary Table (AST) is designed to assist such consideration, ensuring that decision makers are aware of the range and extent of the different project impacts, monetised and non-monetised.

The monetised benefits and costs in CBAs are valued at peoples' willingness-to-pay. The economists' notion of economic efficiency, which underlies CBA, is based on a value judgement of consumers' sovereignty. If decision makers disagree with consumers' valuations of costs and benefits, they may choose to over-ride recommendations based on CBA results.

Adding up gains and losses irrespective of to whom they accrue, CBA does not directly provide information on how the benefits and costs are distributed. Identifying and quantifying the benefits and costs, however, is a first step towards analysis of the distributional consequences of investment projects. Given information on the distributional impacts of projects, decision makers can consider them subjectively. Generally, infrastructure projects are a poor way to redistribute income and wealth from the better-off in society to the less-well-off. In the transport context, equity issues usually relate more to community expectations about accessibility, social cohesion, and equitable funding allocations between regions with different population densities.

The economic benefits from transport initiatives are strongly dependent on demand levels. If funds were allocated purely on the basis of CBA results, the proportion of funds going to less populated areas and the resulting service levels would be too low to gain community support. Inevitably, in the decision making process, a certain amount of economic efficiency has to be given up to accommodate equity considerations. There is no right answer to the amount of economic value to sacrifice to achieve equity objectives. The question can only be resolved subjectively. People accept that infrastructure in less populated areas will be built and maintained to provide lower levels of service compared to more populated areas, but not to the extent that a pure economic approach would dictate. NGTSM (2006, vol. 5, part 1) discusses some ways to promote consistency in decision-making to address equity objectives and safeguards to avoid excessive sacrifice of economic efficiency to promote equity objectives.

Developing a framework in which transparent and consistent decisions can be made to implement initiatives with BCRs below one for social or equity reasons is an area for future research. Such a framework should aim to ensure that

- The trade-offs between economic efficiency and equity, and between levels of equity achieved for different regions or groups are made clear to decision makers
- The maximum equity gain is achieved for a given economic efficiency cost, or a given equity gain is achieved with the least efficiency cost

- There is consistent treatment between different disadvantaged regions or groups such that different regions or groups with the same levels of disadvantage and the same costs of addressing those disadvantages receive similar levels of support.

These issues will be consider in a research project BITRE intends to commence in 2015 on community service obligations for road provision.

Recent developments

Induced Demand

For major urban road and public transport projects, demand forecasts should account for user behaviour changes caused by the project. For example, in the case of major urban road projects, it is not sufficient to assume that the only difference between base-case and project-case numbers of peak period users will arise from users switching routes to take advantage of improved speeds on the project route. Such an approach ignores the complexity of real-world responses to major transport investments (Bray 2005).

CBAs of major urban transport projects should adopt a variable origin–destination matrix approach that accounts for the following potential sources of additional peak period demand:

- Changing mode: Public transport passengers switch to car because the improvement makes road travel more attractive than bus or rail. This is the most commonly achievable variable matrix approach in most capital city transport models (SKM 2009)
- Changing destination: Drivers decide to travel to more distant destinations because the improvement makes the journey time acceptable, and
- Changing time of travel: Drivers decide to travel in the peak period because the improvement reduces journey times in the peak period to an acceptable level

The updated NGTSM will provide additional guidance in this area drawing on improvements in modelling techniques over recent years.

Wider economic benefits

The term Wider Economic Benefits (WEBs) refers to a collection of benefit types stemming from market imperfections, that is, prices of goods and services differing from costs to society as a whole. There are three categories of WEBs that may be relevant for transport initiatives.

Agglomeration economies

Agglomeration economies are benefits that flow to firms and workers located in close proximity (or agglomerating). Firms derive productivity benefits from being close to one another and from being located in large labour markets. Greater productivity in agglomerations arises from the fact that firms have access to larger product, input and labour markets. Knowledge and technology spillovers are also important sources of agglomeration effects. Being an unpriced positive externality, agglomeration gives rise to a market imperfection. By bringing firms closer together and closer to their workforces, transport investment can generate an increase in labour productivity above that calculated from the direct user benefits alone (UK DFT 2014).

Calculation of the agglomeration WEB is done by multiplying the change in 'effective density' (an accessibility measure) caused by a transport improvement, by a 'productivity elasticity'. Productivity elasticities vary by location and industry, and the relationship decays with distance. Econometric analyses of detailed firm-level data to estimate productivity elasticities have been undertaken for the UK and New Zealand, but not yet for Australia.

Transport projects can have offsetting negative agglomeration impacts where they shift economic activity away from one location to another. Hence, WEBs can be negative for some proposals. This is sometimes ignored in CBAs.

Output change in imperfectly competitive markets

A reduction in transport costs to business passengers or freight transport allows firms to profitably increase the outputs of the goods or services that use transport in their production. If the prices of the goods and services affected exceed costs, the increase in output will deliver a welfare gain as consumers' willingness to pay for the increased output exceeds the cost of producing it. This welfare gain is on top of the benefit estimated for the associated generated trips in the conventional CBA framework.

For estimating WEBs from output changes in imperfectly competitive markets, UK DFT (2014) recommends a simple approach of applying a 10% percent uplift to business user benefits. The uplift percentage is derived from information about the average elasticity of demand for the goods and services affected and price–cost margins.

Tax revenues from labour markets

Transport costs (including time and reliability) affect individuals' decisions about whether or not to work, where they locate and how far they are prepared to commute. If, as a result of a transport improvement, more people decide to work and some people are prepared to travel further to higher paying jobs, the full benefit *to them* from their additional trips will be captured by conventional CBA methods in estimating benefits from generated trips. However, commuters value benefits in terms of their post-tax incomes. Conventional CBA omits the additional benefit to society of the increase in income tax revenue from the additional earnings that accrues to the government.

Estimation of the WEBs from increased labour market tax revenues requires use of labour supply elasticities to estimate numbers of new workers and workers moving to more productive jobs as a result of a transport improvement.

Need to improve the quality of WEB estimates

Each of these three WEBs is a legitimate benefit in theory, but there are serious measurement difficulties. So much so that BCRs and NPVs are often presented first *without* WEBs, and then *with* WEBs, almost as if adding WEBs was a sensitivity test.

The 2006 NGTSM does not include guidance on WEBs. Infrastructure Australia's 2008 Reform and Investment Framework introduced WEBs to Australian transport guidelines drawing on the UK guidance in this area. However, Infrastructure Australia has treated WEBs separately from the conventional CBA, treating each case on its merits.

Infrastructure Australia (2013b) states:

> 'While it is recognised that the calculation of these wider benefits is still in its infancy, both in Australia and internationally, Infrastructure Australia believes the correct interpretation and accurate calculation of WEBs (using the most suitable data available) can add texture to the decision making process for certain proposals. However, it is crucial to acknowledge that:
>
> - Only certain proposals will generate WEBs
> - Significant WEBs will only be found in proposals with strong traditional benefits, since WEBs require high levels of behaviour change, e.g. strong demand for the new asset
> - WEBs may be negative for some proposals, and
> - The availability of Australian specific data needed to calculate WEBs is currently sub-optimal.'

The Infrastructure Australia guidelines also note that it is bad practice to simply gross up benefits by a factor to allow for WEBs.

Agglomeration effects, usually the largest source of WEBs, are only likely to be significant for projects that improve access to CBDs and other business districts of capital cities. The Revised NGTSM will include a new section on WEBs that will recommend circumstances under which WEBs should be estimated. This high level guidance will be included in the November 2014 initial refresh of the NGTSM.

The productivity elasticities currently available in Australia can generally be best described as very approximate having largely been derived from highly aggregated data. The NGTSM Review is investigating the econometric modelling and data requirements to obtain a robust set of productivity elasticities for Australia, as well as the parameters needed to estimate the other WEBs. During 2014-15, the Review will commission econometric work and purchase of data from the Australian Bureau of Statistics to obtain the best possible set of parameters obtainable using currently available data for publication in the Guidelines. It is hoped that, in the future, users of project appraisal results will be able to have greater confidence in WEBs estimates where they have been made using the NGTSM methodology and parameter values.

Productivity metrics

Considerable attention is now being given to the impact of infrastructure investment on productivity. In 2012, the NSW Government proposed the 'productivity metrics' concept. The concept is now being further developed by the NGTSM Review in consultation with jurisdictions and will be included in the revised NGTSM.[7]

Productivity benefits are those that directly affect GDP. The main productivity benefits are WEBs and benefits that accrue to freight transport and business travel by private and public transport (time and vehicle operating costs savings; also reliability improvements if they can be valued). The main non-productivity benefits are those that accrue to non-work travellers. There would be some productivity-improving elements in safety and environmental benefits but these are difficult to separate out and relatively small in size for most large projects. The most useful productivity metrics

[7] The 'productivity metrics' concept proposed by the NSW Government for project appraisal is not related to the 'productivity metrics' framework being implemented by the Victorian Government Department of Treasury and Finance for measuring and tracking productivity in the construction of infrastructure and buildings.

are the NPV of a project's productivity benefits, the 'productivity BCR', that is, productivity benefits divided by investment costs, and productivity benefits as a percentage of total benefits.

As WEBs are a major component of productivity metrics, the interest in productivity impacts of transport projects has heightened the need to improve the quality of WEBs estimates.

Productivity metrics can complement the core decision-making tool of CBA by providing an additional layer of information to decision makers. Ways in which the concept can be used include:

- Productivity metrics can be presented in appraisal summary tables for decision makers to consider alongside other information on project impacts and the full CBA results
- Productivity metrics may be included in strategic merit tests where improving productivity is a program objective
- Information on productivity impacts may be useful to governments to help explain the value of individual projects or entire programs, and
- A project's productivity benefits are the subset of benefits that are the inputs required for
    - national economic models (computable general equilibrium models) to estimate the macro-economic, industry and regional impacts of projects, and
    - estimation of impacts on tax revenues.

It is important to recognise that CBA is the only measure of net economic welfare benefits to society and therefore will remain the primary tool to appraise and prioritise projects. Indeed, prioritising projects by productivity BCR instead of conventional BCR could result in significant losses of other benefits, mainly savings in travel time for non-business car and public transport users, because a pure productivity metrics approach attaches zero weight to all non-productivity benefits. Sole reliance on productivity metrics to make decisions is to be avoided.

A compromise approach to prioritisation uses BCRs that retain all the non-productivity benefits but give the productivity benefits a weight greater than one. Projects would then be prioritised using the adjusted BCR obtained from the weighted sum of project benefits (including WEBs). The size of the weight represents the value decision makers place on additional productivity benefits. For example, say the weight was two. Pairs of projects would swap places in the priority order (of descending BCRs) only when each additional dollar of productivity benefit gained from the swap came at a sacrifice of less than two dollars of non-productivity benefit. More expensive reorderings of priorities in terms of non-productivity benefits forgone in order to gain additional productivity benefits, would not occur. The weighting approach offers a simple and transparent approach to reconcile decision making using social and productivity BCRs while controlling the potential economic efficiency losses.

Conclusion

Best practice in the planning and appraisal of transport systems involves use of the frameworks provided by the NGTSM and Infrastructure Australia. Their use ensures that

- Strategies, plans and projects are directed at contributing to high-level national and jurisdictional goals
- Integrated transport and land use planning sets the broad direction for achieving those goals

- Project proposals are consistent with the broader integrated transport and land use plans and are aimed at solving priority problems, and
- The best strategies, plans and projects are identified through sound, rigorous and evidence-rich assessment processes.

CBA is the primary tool used in the appraisal of project options and for the prioritisation of projects across a broader program of projects. CBA is not a perfect tool. Results vary with the assumptions analysts choose to make and some of the parameter values employed are highly approximate. There is risk and uncertainty in forecasts and project proponents and analysts have a tendency towards optimism bias. There is room for considerable improvement in the way some benefits and costs are valued and there are some unresolved issues about methodology and parameter values such as the discount rate.

However, CBA is by far the most rigorous and comprehensive tool available. It is a disciplined approach to considering almost the full range of potential project impacts and attempts to quantify them as far as possible in a consistent and rigorous manner. It enables projects and options to be compared within and between modes, sectors and jurisdictions.

Checking of CBAs by independent reviewers and public release can help ensure the methodology has been correctly applied and that the assumptions are reasonable. Good documentation is invaluable to support checking. Guidelines such as the NGTSM help to improve the quality of CBAs, standardise methodologies and parameters to enhance comparability, make it easier to undertake and review proposals, and give decision makers greater confidence in the results.

A CBA cannot be undertaken without first identifying a project or option to appraise. The broader goal, problem and option generation phases give rise to potential projects to appraise. CBA is undertaken in parallel with a range of other assessment processes. After the CBA, there are processes in the NGTSM to bring together all the relevant information to assist decision making and, following implementation, to undertake post-completion reviews.

Too much reliance on CBA results early in the appraisal process when making plans and exploring options can inhibit the best ideas from emerging. However, caution is warranted in the later stages when CBA results are weighed up together with strategic and other considerations in decision making. CBA measures projects' contributions to the economic efficiency objective. Non-monetised benefits and cost, omitted from CBAs due to valuation difficulties, also count towards economic efficiency and so do not necessarily give rise to an economic efficiency cost when they affect project rankings. But too much sacrifice of economic efficiency by altering the BCR-based prioritisation to emphasise other objectives can be costly. Pickford (2013) argues that the New Zealand approach, which requires a project to attain a BCR above one but then gives a high weight to 'strategic fit' and 'effectiveness' in prioritisation, has favoured low-BCR projects over high-BCR projects at a considerable cost to the economy in terms of forgone benefits. Reducing the importance of CBA in decision making can be costly. A cautious approach is needed for incorporating other objectives such as equity and promoting productivity into decision making.

References

Austroads 2009, *Guide to road transport planning*, Publication no. AGRTP/09, Austroads, Sydney, https://www.onlinepublications.austroads.com.au/items/AGPE04-12

Bray D. 2005, Improving economic evaluation of urban transport projects in Australia, Paper presented at the *Australasian Transport Research Forum* Conference, http://www.atrf.info/papers/2005/2005_Bray_a.pdf

Dobes L. 2008, Getting real about adapting to climate change: Using 'real options' to address the uncertainties, *Agenda*, 15(3), http://press.anu.edu.au/titles/agenda-a-journal-of-policy-analysis-and-reform-2/

Dobes L. and Bennett 2009, Multi-Criteria Analysis: "Good enough" for government work? *Agenda* 16(3),), http://press.anu.edu.au/titles/agenda-a-journal-of-policy-analysis-and-reform-2/

Ergas H. 2009, In defence of cost–benefit analysis, *Agenda* 16(3), http://press.anu.edu.au/titles/agenda-a-journal-of-policy-analysis-and-reform-2/

Evans and Peck 2008, *Best practice cost estimation standard for publicly funded road and rail construction*, Report prepared for the Department of Infrastructure, Transport, Regional Development and Local Government, 19 June, http://investment.infrastructure.gov.au/publications/administration/pdf/Best_Practice_Cost_Estimation.pdf

Harrison, M. 2010, *Valuing the Future: The Social Discount Rate in Cost-Benefit Analysis*, Visiting Researcher Paper, Productivity Commission, http://www.pc.gov.au/research/visiting-researcher/cost-benefit-discount

HM Treasury 2011, *The Green Book: Appraisal and evaluation in central government*, London, https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government

Infrastructure Australia 2013a, *Better infrastructure decision-making*, December, http://www.infrastructureaustralia.gov.au/priority_list/submissions.aspx (under 'Guidelines to making submissions to Infrastructure Australia').

Infrastructure Australia 2013b, *Infrastructure Australia's Reform and Investment Framework, Templates for use by proponents, Templates for Stage 7, Solution evaluation, (Transport infrastructure)*, December, http://www.infrastructureaustralia.gov.au/priority_list/submissions.aspx

National Guidelines for Transport System Management in Australia (NGTSM) 2006, five volumes, http://www.scoti.gov.au/publications/

NSW Government Finance and Services 2014, *Benefits Realisation Management Framework*, http://finance.nsw.gov.au/content/benefits-realisation-management-framework

Linquiti P. and Vonortas N. 2012, The value of flexibility in adapting to climate change: A real options analysis of investments in coastal defense, *Climate Change Economics*, 3(2), http://www.worldscientific.com/doi/abs/10.1142/S201000781250008X?journalCode=cce

Pickford, M. 2013, State highway investment in New Zealand: the decline and fall of economic efficiency, *Policy Quarterly*, 9(3), http://apo.org.au/research/state-highway-investment-new-zealand-decline-and-fall-economic-efficiency

Productivity Commission 2012, *Barriers to effective climate change adaptation*, Report no. 59, Final inquiry report, Canberra, http://www.pc.gov.au/projects/inquiry/climate-change-adaptation/report

Productivity Commission 2014, *Public infrastructure*, Inquiry Report no. 71, Volume 1, Canberra, http://www.pc.gov.au/projects/inquiry/infrastructure/report

Quiggan J. 2005, Risk and discounting in project evaluation, in Bureau of Transport and Regional Economics 2005, *Risk in cost–benefit analysis*, Report 110, http://www.bitre.gov.au/publications/2005/report_110.aspx

Sinclair Knight Merz 2009, *Critical review of transport modelling tools*, Report prepared for the National Transport Modelling Working Group, https://www.bitre.gov.au/publications/2009/cr_001.aspx

UK Department for Transport 2014, *Transport Analysis Guidance (TAG) Unit A2.1: Wider Impacts*, https://www.gov.uk/government/publications/webtag-tag-unit-a2-1-wider-impacts