Evaluating urban railway development projects – an international comparison

Evan Gwee[1], Graham Currie[1], John Stanley[1,2]

[1] Institute of Transport Studies, Monash University
[2] Bus Association Victoria

1 Introduction

Cost-Benefit Analysis (CBA) is an assessment method that was developed for the evaluation of public policy issues and projects (Nas, 1996; Boardman *et al.*, 2006). Today, CBA is widely used in the evaluation of major transport investment projects such as urban rail projects to ensure that they represent an efficient use of the society's resources (Keegan *et al.*, 2007; Nash, 1993). The importance of CBA in the evaluation of public transport projects is highlighted by the Transportation Research Board (TRB, 1998) who suggested that, with the increasing constraints on public funding and the sheer competition of public schemes across the whole sphere of government, urban rail proposals have to "prove their mettle by passing strict cost-benefit assessments".

According to Nash (1993), transport was amongst the first fields where CBA was regularly used as part of decision making. Despite this heritage there remain significant differences in the CBA approaches for rail projects amongst countries (Hayashi and Morisugi, 2000; Nakamura, 2000). These differences can be of interest because:

- they illustrate alternative viewpoints of CBA application and highlight the key issues which are critical to get right from the on-start of a rail CBA
- partly related to this, they can indicate new and innovative approaches to appraisals which may suggest improvements that can be made to the Australian guidelines
- they can also illustrate points of contention within CBA application and these are often a useful focus for research.

While earlier papers (e.g. Hayashi and Morisugi, 2000; Nakamura, 2000) have compared national differences in general CBA applications, this paper expands on this analysis by:

- including more countries in the comparative framework
- contrasting strategic differences and parameter valuation approaches in detail
- illustrating the implications of these differences with a case study.

This paper compares CBA approaches to urban rail project evaluation in Australia, the US, the UK, Canada, New Zealand, Germany, Holland, France, Japan, Hong Kong, the Republic of Korea and Singapore. The key findings on the different aspects of the CBA framework from a strategic viewpoint, as well as the different parameter values adopted, are presented. In each case the analysis presented is based on published evidence. Published evidence can lag behind the practice of evaluation in this field and hence this exercise may not have included the latest development in national CBA applications. This is a limitation which this research has had to accept. In most cases published National Guidelines were used to inform about CBA approaches. For Japan, France, Germany, Hong Kong, Republic of Korea and Singapore the guidelines are not published or available for our analysis. In these cases, CBA approaches were derived from research papers (Morisugi, 2000; Quinet, 2000; Rothengatter, 2000), or obtained via email correspondence with the relevant authorities.

This paper is structured as follows:

- Section 2 presents a discussion of strategic differences in CBA frameworks
- Section 3 discusses parameter valuation evidence assembled in the review
- Section 4 outlines the case study methodology adopted
- Section 5 discussion the findings of the case study.

The paper concludes with a summary of key findings.

2 Strategic Frameworks

Table 1 outlines a comparison of CBA approaches among the twelve countries studied.

2.1 Role of CBA

All countries adopt a multi-criteria analysis (MCA) for project evaluation with CBA being one of the key components. There is some variation in how CBA is used. Project evaluation is usually supplemented with other specialised studies such as an Environmental Impact Statement. The results of the MCA are usually then summarised in a tabular format, showing both monetised and non-monetised impacts. This is to allow decision-makers to subjectively assess monetised and non-monetised impacts. Examples of the tabular summary include the Australian Appraisal Summary Table and the Japanese Benefit Incidence Table.

2.2 Cost components

All the countries include capital, operating and maintenance costs in CBA. Most treat land and property acquisition costs as part of the project's cost and these are valued at market value. Costs associated with mitigation measures related to negative impacts of a project are also usually included. In addition, the US and Australian guidelines further stipulate that the costs of required improvements on other parts of the transport system as a result of implementing the new rail proposal should be included as a cost component in the CBA.

Only the US, New Zealand, Germany and Singapore do not consider residual value of assets in CBA. The other countries either treat residual value as a negative cost in the last appraisal year or record it as an initiative benefit to account for the benefits that the proposal can provide beyond the assessment period. Among them, the UK and the Netherlands further specify a criterion for the inclusion of residual value. Under their guidelines, residual values are considered only for projects with finite lives less than 60 years and 100 years respectively in the English and Dutch guidelines.

2.3 Monetised benefit components

There is more variation in monetised benefit assessment in the approaches reviewed. Benefits are generally classified as Direct and Indirect benefits. Direct benefits are those that are associated directly with activity of travel itself and its effect on users while Indirect benefits are those that are generated over and above the direct benefits which accrue to users of the rail system.

2.3.1 Direct benefits

Direct benefits comprise mainly travel time savings and reductions in operating and accident costs. These benefits can be estimated for 4 main groups namely the public transport (PT) users, automobile users, truck users (or cargo transit users) as well as pedestrians and cyclists as shown in Table 1:

- *Public Transport (PT) Users:* All the countries consider the travel time savings and fare savings as a benefit for PT users which would include existing PT users, diverted PT users (whose trip were previously made on another PT service), former car drivers and passengers. The benefit for existing PT users is generally reflected as a savings in the generalised cost of travel which is a function of travel time (i.e. walk, wait, transfer and in-vehicle time) savings and fare. The benefits to the diverted PT users as well the former car drivers and passengers are generally estimated as one-half of the unit benefit accruing to an existing PT user. Canada is the only country that requires a separate consideration of "small travel-time savings" of less than 5 minutes per one-way trip. They view that small travel time savings are unlikely to be put into any productive use. Hence while such benefits are clearly identified, they are not included in the CBA calculation.

- *Automobile Users:* Congestion relief is estimated in CBA by all the countries excluding Japan. This benefit is measured largely in terms of travel time savings as well as a reduction in operating costs for those drivers who chose to continue to stay on the road network after the implementation of the rail initiative. Australia and the US take the view that transit improvements may effect relatively long-run decisions including the decisions to own motor vehicles. Hence savings in terms of vehicle ownership and the subsequent maintenance costs are considered in their CBA approaches.

- *Truck Users / Freight or Cargo Transit* The US, New Zealand, Canada, Australia, Hong Kong and Singapore include travel time savings, operating costs reduction as well as savings in time-related inventory costs for truck users (or goods vehicles) in CBA. Clearly this parameter is a valid factor where road freight volumes are significant or where the value of the cargoes involved is valuable (TRB, 2002). These benefits are estimated explicitly in the US, New Zealand and Canadian guidelines. In the Australian, Hong Kong and Singapore's approaches freight impacts are estimated using the average resource value of time for goods vehicles which is an input in the estimation of the travel time savings for these vehicles.

- *Pedestrians and Cyclists* Explicit consideration of the impacts on former cyclists and pedestrians who switch to public transport are included in the Australian and American CBA. However, the guidelines involved caution these impacts should only be considered if they are expected to be substantial. Other countries such as the UK assesses such impacts qualitatively and do not include them explicitly within the CBA.

Avoided 'Base Case' cost savings

A CBA is essentially a comparison between a Base case and a Project case. Usually, the Base case consists of whatever would be done in the absence of the any rail initiative. Hence, some countries treat the avoided Base case cost savings as a benefit in their CBA.

Accident cost savings

All the countries included accident cost savings resulting from reductions in road travel with CBA frameworks. However there is much variation in the unit road accident costs adopted. While the Australian and New Zealand guidelines highlighted that savings due to a reduction in the potential conflicts between modes (for example rail and passenger car) can be considered as a positive benefit, no rail prediction model or accident rates are available in the guidelines.

2.3.2 Indirect Benefits

Indirect benefits are those generated over and above the direct benefits that accrue to users of the rail system and comprise largely the positive effect to environmental externalities such as air quality and noise impact. In addition, several countries have also included wider economic benefits such as Option Value and Agglomeration Benefits into CBA.

Environmental externalities

All countries except Hong Kong and Singapore have evaluated and monetised environmental externalities in CBA. These include air pollution and noise impacts.

Approaches in Canada and the Netherlands stress the need to quantify environmental impacts although no specific methodology to do this is detailed in their guidelines. The New Zealand guidelines have the longest checklist of environmental impacts (including visual impact as well as overshadowing impact[1]) to be examined as part of their project evaluation. However these impacts are examined separately from the overall quantitative CBA appraisal. The UK guidelines also recommend the assessment of the environmental impacts outside the CBA framework.

Air pollution and greenhouse emission impact

Most countries consider the intensity of pollutants including carbon monoxide, particulate matter smaller than 10 microns in diameter, hydrocarbons and oxides of sulphur and nitrogen. Japan measures only the level of nitrogen oxide emissions. Air pollution and greenhouse gas impacts are included in CBA approaches in Australia, New Zealand, France and Japan.

Noise impact

As mentioned earlier, noise impact is one of the two most common externalities that are included in CBA internationally. Most countries estimate a monetary value using a hedonic pricing method approach except Germany which bases their value on the cost for equipping houses with noise-proof glazing.

Water quality and nature impacts

These are included in CBA approaches in selected countries. Water quality impact is in the US and Australian guidelines. Canada and the Netherlands recommend measuring these impacts as far as possible while in New Zealand this impact is assessed in a study separate to the CBA. There is no mention of these impacts in the CBA guidelines of the other countries assessed.

In terms of impact on nature, Australia is the only country that requires the quantification of impacts in CBA. New Zealand guidelines assess natural impacts separately from the CBA. Other countries include the cost of the mitigating impacts on nature measures as part of the project costs. Hence, while these countries do not monetise the impact of transport on nature directly as “benefits”, these impacts are assessed indirectly in terms of mitigation costs and incorporated in the overall project costs.

[1] According to the New Zealand guidelines, this impact examines the reduction in the amount of direct sunlight onto the adjourning property.

Option value

Option Value (OV) is the "willingness-to-pay to preserve the option of using a transport service for trips not yet anticipated or currently undertaken by other modes over and above the expected value of any such use" (Laird *et al*., 2007). The US is the only country to include OV in their appraisal framework.

Agglomeration benefits

The other area of recent international interest is the consideration of wider agglomeration benefits in transport appraisals (Keegan *et al*., 2007). Agglomeration benefits result from the increase in productivity, creativity and synergy amongst firms because of a higher concentration of firms or higher density of employment made possible by more compact, transit-served development (TRB, 1998; Vickerman, 2007). As can be seen from Table 1, only the German and Dutch guidelines have incorporated this benefit in their CBA.

According to Keegan *et al*. (2007), there has been no significant research carried out in this area to date. Eddington (2006) highlighted that the agglomeration effects could increase the overall project benefits of transport projects 'by up to 50 per cent in some cases'. Vickerman (2007) agreed and estimated that the wider economic benefits' generated by rail projects may amount to as much as 55 per cent of the direct transport benefits'. Despite these findings, agglomeration benefits are not included in the UK guidelines or in CBA approaches for most countries.

Enhancement to property values

The explicit enhancement of property values as part of CBA is suggested in the Netherlands. Van der Hoorn (2008) and Zwartjies (2007) recommend the inclusion of enhancement to property values for larger Dutch transport projects e.g. the high speed rail link from Schiphol to Groningen. However, these benefits are not mentioned in the Dutch national guidelines. Other guidelines have suggested this is 'double counting' of travel time (user) benefits.

2.4 Accounting approaches

Social Discount Rates (SDR)

Table 1 illustrates a range of approaches to SDR development. The most common is the marginal rate of return on private-sector investment which is adopted by the US, New Zealand, Canada, Hong Kong and the Republic of Korea. This approach yields a SDR of 6-10%.

The UK is the only country to stipulate different SDR for different evaluation periods:

- 3.5% (for 0-30 years)
- 3.0% (for 31-75 years)
- 2.5% (after 75 years) although it is highlighted that transport projects are unlikely to require appraisal that far into the future.

The Australian guidelines do not specify a SDR but recommend that the evaluation use the SDR nominated by the funding body. Hong Kong uses a similar approach. The Canadian guidelines are the only one to state an explicit range of discount rates for sensitivity analysis.

Assessment Period

The most common evaluation period appears to be 20-30 years. The Netherlands and Hong Kong tagged their assessment period to the types of transport projects that they are evaluating. In these cases evaluations up to 100 years or more can be carried out.

Decision Criteria

There are three decision rules which are more commonly employed in CBA:

- Net Present Value (NPV)
- Benefit-Cost Ratio (BCR)
- Internal Rate of Return (IRR).

NPV is the most common decision criteria. IRR is always taken as a second decision criterion by countries apart from the NPV. No countries adopt the IRR as the only decision criterion. France and New Zealand use the First Year Rate of Return (FYRR, which is equal to the benefit of the first year divided by the cost of the investment) to check the year of implementation of their projects. Provided certain assumptions hold, the optimum year of implementation is when the FYRR is equal to the discount rate.

Most countries require a BCR greater than 1. In Germany, a project needs to achieve a BCR value greater than three before it is included in the upcoming 20 year plan; otherwise it will be allocated to the waiting list and be re-evaluated again with the proposals for the next 20 years. Rottengatter (2000) highlighted that this is due to expected double-counting of regional economic effects in the German method which was deliberately built-in to mitigate equity issues among regions. According to the German approach, in the BCR of projects in the 20 regions with the lowest Gross Value Added per capita, the employment effects during the construction and subsequent operation of the proposed infrastructure are magnified.

3 Parameter Valuations

This section examines parameters included in rail CBA approaches in broadly 3 categories; Value of Private Time (VOT), accident costs and values of externalities. Results are indicated in Table 2.

To aid comparison, parameter values for each country are converted to 2006 Australian dollar. As Willingness-To-Pay (WTP) is a unifying element in values, the change in the average wage of each country provides a good approximation of how WTP would vary over time. Therefore, the parameter values are first updated to 2006 values based on the average wage increment of each country between the date the VOT was captured (as shown in the guidelines) and 2006. The 2006 values are then converted to Australian currency based on the exchange rates provided by the Australian Reserve Bank.

Value of Private Time (VOT)

The VOT data presented concerns the VOT for PT users and car drivers for trips to and from work. This time bracket is chosen as it represents the time period where the passenger ridership and vehicular traffic is the highest in the network and hence the VOT value is expected to have the most significant implication to the appraisal. Two methods for VOT are adopted in the CBA approaches examined:

- the wage-rate approach
- the stated preference (SP) or revealed preference (RP) approach.

As Table 2 shows, the VOT for commuting trips to and from work ranges from about A$5/hour (for Singapore and Hong Kong) to A$15/hour (for the Netherlands). This significant discrepancy in the VOT value can largely be attributed to the different wage rate, relative proportion of work and non-work hours as well as tax rate of each country. The implication is that for the same project travel time savings, countries like the Netherlands would value benefits three times more than that in Singapore. This implication is significant given the dominant role of travel time savings in urban rail appraisals.

Most of the countries adopt a similar VOT value for PT users and car users. For New Zealand, Hong Kong and Singapore, a higher VOT is used for car users as compared to PT users while the Netherlands adopt a slightly lower VOT for the car users instead. The observed average VOT for commuting to and from work of these countries is about A$10 for PT users and A$10.50 for car users.

The VOT of most countries is about 30-50% of the average hourly wage rate.

Accident Costs

Two approaches are used to estimate accident costs in the CBA approaches examined:

- the Human capital approach
- the Willingness to Pay approach.

The human capital approach involves estimating the discounted present value of all costs arising from a crash that can be directly measured, including the loss of future earnings. The WTP approach involves estimating the monetary amount that people are willing to forgo to reduce the risk of death or injury (Australian Transport Council, 2006).

Valuations of mortality accidents are very different between countries (Table 2). The highest value of a fatal accident is A$4.25 million in the UK while the lowest is A$0.1 million as adopted in Singapore. There is also a wide difference in the value of serious accidents and minor accidents amongst countries albeit difference in the definitions of serious and minor accidents is a factor. While each serious accident cost about A$490,000 in the UK, the value is about 8 times lower in Germany at about A$60,000. Likewise, minor accidents are about 9 times more costly in the UK and Canada as compared to Germany and Japan. The US approach applies the same value to serious accidents and minor accidents.

Externality Costs

Broad average valuations for externality costs are shown in Table 2. Most guidelines highlight that these values should be used with caution and that a detailed assessment should be conducted if certain externalities are expected to have a significant impact on the appraisal.

Nash (1997) highlighted that one of the biggest challenges in deriving a monetary value for environmental impacts is ‘that different studies tend to come up with totally different results’ due to the different methods employed as well as the differing principles in the way costs are assessed. This is clearly evident from Table 2 where different countries have derived very different monetary values (or a range of values) for environmental impacts. For example the value of noise pollution is estimated to be about A$0.0015/veh-km in the US, but the Australian guidelines estimated a value of A$0.0080/ veh-km which is about 5 times higher.

4 Case Study Approach

To illustrate the implications of the different CBA approaches examined an example rail improvement project is evaluated. The case study undertaken is a rail electrification project in Melbourne. This project involved the electrification of about 30 km of existing rail tracks as well as the upgrading of the corresponding facilities and vehicles at an estimated project cost of about A$80 million. All CBA approaches are applied to the case study excluding those from the Republic of Korea where no parameter value information is available. In summary the following steps were followed:

- The CBA for each country is applied using the principles defined in Table 1 and the parameter values shown in Table 2.
- To aid comparison all appraisals are carried out in equivalent 2006 Australian dollars.
- Capital and operating cost of the hypothetical rail project is assumed to be the same for all the countries.
- Based on the vehicle operating cost (VOC) values given in the published guidelines of Australia, New Zealand, the US, the UK, Canada and the Netherlands, the VOC for passenger cars (for commuting to / from work) ranges between A$0.14/km to A$0.18/km. An average VOC of A$0.16/km is adopted for countries where VOC values are not published.
- For Canada and the Netherlands, which have indicated that environmental impacts should be quantified and valued as far as possible, a reduction in air pollution, greenhouse effects and noise pollution are included in the economic appraisal.
- For the US evaluation, where Option Values are included, an OV benefit is estimated based on the information provided by TRB (2002).
- Similarly for the Netherlands and German evaluations, which have incorporate agglomeration effects in their CBA, these are benchmarked at 50% of the direct transport benefits as suggested by Eddington (2006) and Vickerman (2007).
- A real social discount rate of 4% and 10% is assumed for Australia and Hong Kong appraisals respectively. This is based on our understanding that the Australian rate is tagged to the Government's borrowing rate while that of Hong Kong is based on the marginal rate of return of private investment.
- For those countries where parameter values are not available, the corresponding Australian values are adopted.

5 Results and Discussion

Table 3 shows the resulting CBA assessments using the above approach. Very different evaluation outcomes emerge. Only the Australian, US, UK and the Netherlands approaches found the proposal economically feasible. It is interesting to note that while Germany has achieved a BCR of 1.31, the proposal is not economically feasible as their decision criteria require the project to have a minimum BCR value of 3 before it will be considered for implementation.

The BCR of the countries that assessed the project to be feasible ranges from 1.00 (of Australia) to 2.61 (of the Netherlands). This is a significant difference and is largely due to the higher VOT adopted in Holland as well as the inclusion of agglomeration benefits in their CBA. The following discussion considers various components of the CBA and results associated with these components.

Value of Private Time (VOT)

Travel time savings contribute about 50-60% of the total benefits generated by the project. On this basis appraisal outcomes can be very sensitive to changes in VOT. For example, if the VOT used in the US assessment is increased by merely 10¢/hour, the project would be economically feasible with a BCR above unity. Clearly it is important that to get VOT estimates right to ensure that benefits are accurately assessed against costs.

Congestion Relief

Most countries included road user travel time savings and vehicle operating costs when estimating congestion relief (e.g. Australian Transport Council, 2006, Land Transport New Zealand, 2007). Congestion relief accounted for about 40-50% of total project benefits. Japan does not include congestion relief benefits. This is a major omission since their BCR would improve significantly from 0.48 – 0.55 to 1.21 – 1.41 if congestion relief was included in their assessment.

Accident Costs

Accident cost savings was observed to contribute not more than 3% of the total project benefits for most countries. For countries such as Singapore and Japan where the accident cost unit values are comparatively very much lower, BCR's would improve, though not by a large margin, if a higher accident cost value is adopted.

Environmental Externalities

The inclusion or omission of environmental externalities in CBA is not a significant factor in the outcome of the rail case study examined. This observation is consistent with the views of the Transportation Research Board (TRB, 2002). From the case study, it is observed that environmental benefits account for about 4% or less of the total project benefits.

Option Value (OV)

The OV benefits in the US CBA are estimated for the scenarios where the car users are willing to "buy" the options to use the rail alternative twice to ten times a year, using estimates from the Transportation Research Board (TRB, 2002). For all scenarios, OV benefits account for no more than 1% of total project benefits on this basis. However, it is probably premature to conclude from this that OV benefits are not important as some studies (such as Laird *et al*., 2007) have suggested that significant OV can be expected to be associated with urban passenger rail systems especially under situations of lack of car availability and a poor bus service, or of severe road congestion and parking difficulties. As "the field of measuring transport option values clearly is far from developed" (Laird *et al*., 2007), further research in this area is warranted.

Agglomeration Benefits

Agglomeration Benefits are included in the Dutch and German CBA analysis. As mentioned in the earlier section, given the absence of a detailed methodology for estimating agglomeration benefits in the Dutch and German guidelines, these wider economic benefits are benchmarked at 50% of the direct transport benefits as suggested by Eddington (2006) and Vickerman (2007). The results of the case study suggested that if these benefits were included in the CBA approaches for all countries, the appraisal outcome would improve significantly.

However, given the lack of research in this area (Keegan *et al*., 2007), countries may have taken a prudent approach to not include these benefits in their current CBA framework. Having said so, a survey or past studies in this area showed that a significantly higher of studies have found a positive connection between transport infrastructure provision and urban productivity. They seem to suggest that agglomeration benefits associated with transport investments are valid. The validity of such agglomeration benefits also stems from the fact that there are no studies to date that suggested the provision of transport infrastructure would impact urban productivity negatively.

The provision of an urban passenger rail system is expected to bring about the following productivity impacts which may generate wider economic benefits that are presently not captured in the conventional CBA framework:

- Broaden access to jobs and labour market which would result in higher employment mobility and therefore enhances employment density – this will create a larger, more specialised work force and also facilitate a greater exchange of knowledge amongst employees.

- Expand market for goods and services which essentially means that firms will be able to trade over a larger area – this will result in a larger client market as well as create a more competitive and complementary business environment where firms would need to be more efficient and innovative and even collaborate so as to lower production costs and bring about increasing returns to scale.

- Improve accessibility to sites and unlocking land – the improved accessibility will improve business reliability and hence improve the firm's competitiveness. In addition, the improved accessibility will not only entice existing businesses to increase their investment on site, it will also attract new firms to set up their businesses in the area. This increase in concentration of businesses will help to expand labour market catchments and facilitate business to business interactions and knowledge transfer.

Given the potential significance of its contribution to the economic viability of transport proposals, further research into the area of agglomeration benefits is indeed important.

Social Discount Rates (SDR)

The case study also highlights the important of using correct SDR values in CBAs. As can be shown mathematically, lower SDR values will result in higher NPV values and that a SDR lower than 4% is likely to always yield a positive NPV for conventional CBA.

6 Conclusions

This paper compares CBA approaches to urban rail project evaluation in Australia, the US, the UK, Canada, New Zealand, Germany, Holland, France, Japan, Hong Kong, the Republic of Korea and Singapore. An assessment of strategic frameworks and individual parameter valuations has been undertaken. A case study evaluation has been undertaken to illustrate the impacts of differences in CBA approaches

All countries adopt a multi-criteria analysis (MCA) for project evaluation with CBA being one of the key components. There is some variation in how CBA is used. In terms of cost components, all the countries consider capital, operating and maintenance costs in their CBA. Some also include the residual value of the assets in their assessment.

There is noticeably more variation in approaches to monetised benefits. Travel time savings are common primary benefits. Japan does not include congestion relief in their CBA. Several countries such as Australia also capture the travel time savings to truck users as well as pedestrians and cyclists in their assessment. Another common benefit that is included in CBA internationally is accident cost savings. However, there is much variation in the unit accident costs adopted.

In terms of secondary benefits, all countries except Hong Kong and Singapore have included the impact on environmental externalities to various extents in their CBA. Among the impacts considered, air pollution and noise impacts are commonly included. The US is the only approach which includes Option Value in their CBA. The approaches in Germany and the Netherlands are the only ones to adopt agglomeration benefits in their economic appraisals.

There are considerable variations in the social discount rates (SDR), the assessment period and decision criteria adopted. Most derive SDR based on the marginal rate of return on private-sector investment which yields a SDR of 6–10%. 20–30 years appears to be the most common evaluation period. In terms of decision criteria, NPV is the most common decision rule among the approaches examined.

Parameter valuations were assessed in comparative terms by standardising to a single currency and year of estimate. The Value of Time (VOT) for commuting trips to and from work is observed to range from A$5-15/hour with an average value of about A$10/hour for PT users and A$10.50/hour for car users. Likewise, the accident cost unit values very between countries. The value of a fatal accident ranges from A$0.1-4.25 million while serious accidents vary between A$60,000 – 490,000. There is also much variation in the monetary valuations for the unit environmental impacts.

To illustrate the implications of these differences, a case study was undertaken. This found very different evaluation outcomes according to the approaches adopted. Only the approaches in Australia, the US, the UK and the Netherlands found the proposal economically feasible with BCR ranging between 1.00 and 2.61. The most important benefits identified from this analysis are travel time savings and congestion relief. These are observed to contribute about 50–60% and 40–50% of the total project benefits respectively. Accident cost savings were observed to contribute no more than 3% of total project benefits while the results of the case study suggest that the impact of environmental externalities in CBA is not significant.

The case study suggest that OV benefits account for no more than 1% of the total project benefits in the US appraisal. However it is acknowledged that OV is a relatively new area in transport economics and hence it is probably too early to conclude that OV benefits are not important. The case study also found that agglomeration benefits would substantially increase project benefits if included in CBA approaches. Given the potential significance of agglomeration benefits, further research into this area is warranted.

In summary, the key finding from the case study is that travel time savings and congestion benefits are important in a rail CBA. It is therefore critical to get VOT estimates right to ensure that these benefits are accurately assessed against costs. In addition, the case study also demonstrated the potential significance of agglomeration benefits. There is therefore motivation to further investigate into this field so that such benefits can be better estimated in order to do proper justification to rail projects. The case study also illustrates that it is important for analyst to use appropriate SDR values in their appraisals as they have great influence in the outcome of the CBA appraisal.

Table 1 – Comparison matrix of the international assessment of urban rail project evaluation approaches

Parameter	Details	Countries	Australia	New Zealand	USA	Canada	UK	France	Netherlands	Germany	Japan	Republic of Korea	Hong Kong	Singapore
Costs		Capital costs	√	√	√	√	√	√	√	√	√	√	√	√
		Operating and maintenance Costs	√	√	√	√	√	√	√	√	√	√	√	√
		Costs of required mitigation measures to reduce the negative effects of the project	√	√		√	√		√	√		√	√	
		Costs of required improvements on other parts of the transport system	√		√									√
		Residual value of the asset	√			√	√	√	√		√	√	√	
Benefits (monetised)	PT users	Travel time savings (including walk, wait, transfer and in-vehicle time)	√	√	√	√	√	√	√	√	√	√	√	√
		Fare savings and out-of-pocket savings	√	√	√	√	√	√	√	√	√			
	Auto users	Travel time savings	√	√	√	√	√	√	√	√		√	√	√
		Operating cost savings	√	√	√	√	√	√	√	√		√	√	√
		Vehicle ownership and maintenance cost savings	√		√									
	Truck users	Travel time savings	√	√	√	√						√	√	√
		Operating cost savings	√	√	√	√						√	√	√
	Pedestrains / Cyclists	Travel time savings	√		√									
		Vehicle ownership and maintenance cost savings	√		√									
	Externalities	Air Pollution	√	√	√	?		√	√	√	√	√		
		Green house emission	√	√		?		√	√		√	√		
		Water quality impact	√		√	?			?					
		Noise impact	√	√	√	?	√	√	√	√	√	√		
		Impact to nature and landscape	√			?			?					
	Others	Accident cost savings	√	√	√	√	√	√	√	√	√	√	√	√
		Savings in "avoided costs"	√	√	√					√				
		Option Value			√		?							
		Agglomeration Benefits					?		√	√				
		Enhancement to Property Values							?					
Discount Rate	Method of Derivation	Based on Marginal Rate of Return on Private Investment		√	√	√						√	√	
		Based on Social Marginal Rate of Time Preference					√							√
		Based on Government's Borrowing Rate	√						√		X			
		Based on Weighted Average Approach												
		Based on 'Shadow Price of Capital' Approach						√						
		Based on the Optimal Growth Rate Approach								√				
	Value Adopted		to use discount rate nominated by funding body	10%	7% - 10%	10%	2.5% - 3.5%	8%	4%	3%	4%	6.5%	depend on rail operator	4%
Evaluation Period (years)			50	25	20	30	60	30	Tied to the lifespan of the project up to a max of 100 yrs	40	30-50	20 - 30	30 - 120	60
Decision Criteria		Nett Present Value (NPV)	√		√	√	√	√	√			√	√	
		Benefit-Cost Ratio (BCR)	√	√						√	√	√		√
		Internal Rate of Return (IRR)						√	√			√	√	

Sources: Developed from (Lam, 2007; ATC, 2006; Eijgenraam *et al*., 2000a;b; Federal Transit Administration, 2007; Hayashi and Morisugi, 2000; HM Treasury, 2003; Land Transport New Zealand, 2005; Land Transport New Zealand, 2007; Lee Jr, 2000; Morisugi, 2000; Nakamura, 2000; Office of Management and Budget, 1992; Planning and Policy Division, 2005; Quinet, 2000; Rothengatter, 2000; Transport Canada, 1994; TRB, 1996, 1998, 2002; Treasury Board of Canada Secretariat, 1998; Vickerman, 2000; Young, 2002; Austroads, 2006; Kim, 2008; Lim, 2008; Zwartjes, 2007; Van der Hoorn, 2008).

Legend

√	**monetised and included**
blank	**not monetised**
X	**no information**
?	**unclear whether the subject parameter is included or not in the CBA**

Table 2 – Comparison of parameter values

Countries / Parameter	Australia	New Zealand	USA	Canada	UK	France	Netherlands	Germany	Japan	Republic of Korea	Hong Kong	Singapore
VOT - commuting to/from work												
PT users (A$2006/hr)	A$10	A$6.42	A$14.01	A$9.56	A$12.10	A$11.41	A$15.07	A$8.59	A$13.85	X	A$4.81	A$5.27
car users (A$2006/hr)	A$10	A$7.59	A$14.01	A$9.56	A$12.10	A411.41	A$14.97	A$8.59	A$13.85		A$7.81	A$6.26
Accident costs												
Fatal Accident (A$mil2006)	$1.85	$2.99	$4.20	$2.39	$4.25 [1]	$1.24	$1.55	$1.33	$0.32	X	X	A$70,000 - A$100,000
Serious Accident (A$2006)	$454,230	$320,970	$14,014	$132,827	$487,535	$127,840	$206,464	$60,663	$96,866			
Slight Accident (A$2006)	$14,014	$18,723		$50,313	$49,677	$27,179	$30,970	$5,257	$6,183			
Externalities												
Air Pollution	A$0.0252 / vkm	A$0.0089 / vkm	ranges from A$0.02/kg of CO to A$20.40/kg of PM10	X	Θ	A$0.0268 / pax km	A$0.0134 / vkm	X	A$5,977 / ton - NOx	X	Θ	Θ
Green house	A$0.0031 / vkm	7.5% of VOC	Θ			A4$0.0081 / pax km	A$0.0103 / vkm	Θ	A$24 / ton-C	X		
Water Quality impact	A$0.0038/ vkm	Θ	A$0.0005 / vkm			Θ	X	Θ	Θ	Θ		
Noise Impact	A$0.0080 / vkm	A$365.55/db/household/yr	A$0.0015 / vkm		ranges from A$24.38 to A$284.40db/household/yr [2]	X	A$0.0052 / vkm	X	A$4,897/db/km/yr	X		
Nature and landscape	A$0.0034 / vkm	Θ	Θ		Θ	Θ	X	Θ	Θ	Θ		

Sources: Developed from (Lam, 2007; ATC, 2006; Eijgenraam *et al*., 2000a;b; Federal Transit Administration, 2007; Hayashi and Morisugi, 2000; HM Treasury, 2003; Land Transport New Zealand, 2005; Land Transport New Zealand, 2007; Lee Jr, 2000; Morisugi, 2000, Nakamura, 2000; Office of Management and Budget, 1992; Planning and Policy Division, 2005; Quinet, 2000; Rothengatter, 2000; Transport Canada, 1994; TRB, 1996, 1998, 2002; Treasury Board of Canada Secretariat, 1998; Vickerman, 2000; Young, 2002; Austroads, 2006; Kim, 2008; Lim, 2008; Zwartjes, 2007; Van der Hoorn, 2008)

Legend

X **no information**

Θ **not assessed**

Notes:
1 – this VOT value is based on the average wage of US$10 per hour (Transportation Research Board, 2002)
2 – In Transportation Research Board (2002), there is no differentiation between serious and minor accidents. Both the accidents are valued at US$10,000 (2002 value).
3 – In Transportation Research Board (2002), each air pollutant has a different monetary value. This is different from the guidelines of Australia, NZ and the Netherlands which has a unified cost value for air pollution.
The values shown in the table are 2002 values.

Table 3 – Evaluation results of case study

Details		Australia	New Zealand	USA	Canada	UK	France	Netherlands	Germany	Japan	Republic of Korea	Hong Kong	Singapore
Social Discount Rate used in Case Study		Assumed 4%	10%	7% - 10%	10%	2.5% - 3.5%	8%	4%	3%	4%	6.5%	Assumed 10%	4%
Evaluation Period (years)		50	25	20	30	60	30	Assumed 50 yrs	40	30-50	20 - 30	30 - 120	60
Evaluation Results	Nett Present Value (NPV) - $000, 2006	$112	-$50,347	$5,927	-$40,583	$47,287	-$9,912	$180,850		-$53,987	Not evaluated	-$60,155	-$65,771
	Benefit-Cost Ratio (BCR)	1.00	0.39	1.07	0.51	1.39	0.90	2.61	1.31	0.48-0.55		0.27	0.43
	Internal Rate of Return (IRR)						5.50%	15.50%				5%	
Evaluation Outcome		√		√		√		√					

Legend

Passed economic appraisal √

Borderline case - depend on assessment period ?

References

ATC (2006). *National guidelines for transport system management in Australia*. Australian Transport Council: Canberra.

Austroads (2006). *Update of RUC Unit Values to June 2005*. Technical Report AP-T70/06. Austroads: Sydney.

Boardman, A., Greenberg, D., Vining, A. and Weimer, D. (2006). *Cost-Benefit Analysis - Concepts and Practice,* Prentice Hall: New Jersey, USA.

Eddington, R. (2006). *The Eddington Transport Study - The case for action: Sir Rod Eddington's Advice to Government*. Her Majesty's Treasury: London, UK.

Eijgenraam, C. J. J., Koopmans, C. C., Tang, P. J. G. and Verster, A. C. P. (2000a). *Evaluation of infrastructural projects: Guide for cost-benefit analysis - Section 1: Main Report*. Ministry of Transport Public Works and Water Management and the Ministry of Economic Affairs: The Netherlands.

Eijgenraam, C. J. J., Koopmans, C. C., Tang, P. J. G. and Verster, A. C. P. (2000b). *Evaluation of infrastructural projects: Guide for cost-benefit analysis - Section 2: Capita Selecta*. Ministry of Transport Public Works and Water Management and the Ministry of Economic Affairs: The Netherlands.

Federal Transit Administration (2007). *Procedures and Technical Methods for Transit Project Planning (Alternatives Analysis Technical Guidance)*. Department of Transportation: Washington, DC, USA.

Hayashi, Y. and Morisugi, H. (2000). 'International Comparison of Background Concept and Methodology of Transportation Project Appraisal'. *Transport Policy,* 7, pp. 73-88.

HM Treasury (2003). *Appraisal and evaluation in central government*. (The Green Book). Her Majesty's Treasury: London, UK.

Keegan, M., Favero, G. and Porter, C. (2007). Transport Appraisal: Are we including all the benefits ? *UITP Magazine PT International,* Nov / Dec issue.

Kim, K. S. (2008). *The cost-benefit analysis framework of the Republic of Korea*. [online]. Message to: Gwee, E. [Accessed 9 January 2008]. Personal communication.

Laird, J., Geurs, K. and Nash, C. (2007). *Option and non-use values and rail project appraisal*. Department of Transport: London, UK.

Lam, A. (2007). *The cost-benefit analysis framework of Hong Kong*. [online]. Message to: Gwee, E. [Accessed 14 December 2007]. Personal communication.

LTNZ (2005). *Economic evaluation manual*. Volume 2. Land Transport New Zealand.

LTNZ (2007). *Economic evaluation manual*. Volume 1. Land Transport New Zealand.

Lee Jr, D. B. (2000). 'Methods for evaluation of transportation projects in USA'. *Transport Policy,* 7, pp. 41-50.

Lim, W. L. (2007). The cost - benefit analysis framework of Singapore. [online]. Message to: Gwee, E. [Accessed 3 December 2007]. Personal communication.

Morisugi, H. (2000). 'Evaluation methodologies of transportation projects in Japan'. *Transport Policy,* 7, pp. 35-40.

Nakamura, H. (2000). 'The economic evaluation of transport infrastructure: Need for international comparison'. *Transport Policy,* 7, pp. 3-6.

Nas, T. F. (1996). *Cost-benefit analysis: Theory and application,* Sage Publications: Thousand Oaks, London.

Nash, C. (1993). 'Cost-benefit analysis of transport projects'. In Williams, A. and Giardina, E. (Eds.) *Efficiency in the public sector: The theory and practice of cost-benefit analysis.* Edward Elgar: Aldershot, UK.

Nash, C. (1997). 'Transport externalities: does monetary valuation make sense?' In Rus, G. D. and Nash, C. (Eds.) *Recent developments in transport economics.* Ashgate: UK.

Office of Management and Budget (1992). *Guidelines and discount rates for benefit-cost analysis of federal programs*. Office of Management and Budget.

Planning and Policy Division. (2005). *Guideline on economic, social and environmental cost-benefit analysis*. Department of Infrastructure: Victoria.

Quinet, E. (2000) 'Evaluation methodologies of transportation projects in France'. *Transport Policy,* 7, 27-34.

Rothengatter, W. (2000) 'Evaluation of infrastructure investments in Germany'. *Transport Policy,* 7, 17-25.

Transport Canada (1994). *Guide to benefit-cost analysis in Transport Canada*. Transport Canada

TRB (1996). *Measuring and valuing transit benefits and disbenefits*. Transit Cooperative Research Program (TCRP) Report 20. Transportation Research Board: Washington, DC, USA.

TRB (1998). *Economic impact analysis of transit investments: Guidebook for practitioners*. Transit Cooperative Research Program (TCRP) Report 35. Transportation Research Board: Washington, DC, USA.

TRB (2002). *Estimating the benefits and costs of public transit projects: Guidebook for practitioners*. Transit Cooperative Research Program (TCRP) Report 78. Transportation Research Board: Washington, DC, USA.

Treasury Board of Canada Secretariat (1998). *Benefit-cost analysis guide*. Treasury Board of Canada Secretariat: Canada.

Van der Hoorn A.I.J.M. (2008). *Cost-benefit analysis practice in the Netherlands*. [online]. Message to: Gwee, E. [Accessed 2 January 2008]. Personal communication.

Vickerman, R. (2000). 'Evaluation methodologies for transport projects in the United Kingdom'. *Transport Policy,* 7, 7-16.

Vickerman, R. (2007). *Provision of public transport under conflicting regulatory regimes*. 10th international conference on competition and ownership in land passenger transport.

Young, L. (2002). *Determining the discount rate for government projects*. Working Paper 02/21. New Zealand Treasury: Wellington.

Zwartjes, S. (2007). *The cost benefit appraisal framework of the Netherlands*. [online]. Message to: Gwee, E. [Accessed 12 December 2007]. Personal communication.