International Variation in Cost–Benefit Analysis of Urban Rail Projects

Impact on Outcomes

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This paper compares urban rail cost–benefit analysis (CBA) in 11 countries and the region of Hong Kong, China, to understand differences and implications for evaluation outcomes and to highlight possible CBA improvements. All countries studied used multicriteria analysis and examined capital, operating, and maintenance costs, and some included asset residual value. Monetized benefits varied, although travel time savings (TTS) were common primary benefits. Several countries also captured TTS for trucks, pedestrians, and cyclists. Accident cost savings (ACC) were common, although unit accident costs varied. For secondary benefits, all countries and regions except Hong Kong and Singapore included environmental externalities. Air pollution and noise impact were common. The United States was unique in including option value, and Germany and the Netherlands were unique in adopting agglomeration benefits. The social discount rate (SDR), assessment period, and decision criteria varied. Most SDRs used the marginal rate of return on private-sector investment (yielding an SDR of 6% to 10%). Net present value was the common decision criterion, and 20 to 30 years was a common evaluation period. Standardized parameter valuations suggested commuting value of time as $5 in Australian dollars per hour (A$5/h) to A$15/h, with an average of A$10/h for public transport users and A$10.50/h for car users. Accident cost varied; fatal accidents cost A$0.1 to A$4.25 million and serious accidents A$60,000 to A$490,000. A case study illustrates implications of adopting approaches with varied outcomes. Only Australia, the United States, the United Kingdom, and the Netherlands had positive benefit–cost ratios (1.00 to 2.61). TTS and congestion relief were major benefits (50% to 60% and 40% to 50%, respectively, of all benefits). ACC, environmental externalities, and option value benefits were not significant. Agglomeration benefits substantially increased project benefits.

Cost–benefit analysis (CBA) was developed as an assessment method for the evaluation of public policy issues and projects (*1–3*). Today, CBA is widely used in the evaluation of major transport investment projects, such as urban rail projects, to ensure they generate optimum returns (*4, 5*). The importance of CBA in the evaluation of public transport (PT) projects is highlighted by TRB, which suggests that the increasing constraints on public funding and the sheer competition of public schemes across the whole sphere of government mean that urban rail proposals must "prove their mettle by passing strict cost–benefit assessments" (*6*).

According to Nash, transport was among the first fields in which CBA was regularly used as part of decision making (*5*). Despite this heritage significant differences remain in approaches to rail project evaluation in countries (*7, 8*). These differences can be of interest because

- They illustrate alternative views on CBA application,
- They can indicate new and innovative approaches to appraisals,
- They inform the development of guidelines to reflect the most appropriate methods, and
- They can illustrate points of contention within CBA application that are often a useful focus for research.

While earlier papers have compared national differences in general CBA applications (*7, 8*), this paper expands on this comparative analysis by

- Including more countries in the comparative framework,
- Contrasting the strategic differences and parameter valuation approaches adopted in greater detail, and
- Illustrating the implications of these differences with a case study.

This paper compares CBA guidelines for urban rail project evaluation in Australia, the United States, the United Kingdom, Canada, New Zealand, Germany, the Netherlands, France, Japan, Hong Kong, South Korea, and Singapore. A major motivation for this analysis was to understand differences in approaches adopted, as these differences might inform best practices in the field. 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. The collected evidence is largely based on published economic assessment guidelines produced by national governments to provide a general overarching framework for the appraisal of publically funded projects. For Japan, France, Germany, Hong Kong in China, South Korea, and Singapore such guidelines were not published or available; in these cases, CBA approaches were derived from Morisugi (*9*), Quinet (*10*), and Rothengatter (*11*) or obtained via email correspondence with the relevant authorities. Economic assessment is usually carried out as part of the local or strategic planning process as a precursor to the application of government

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funding. Published evidence can, however, lag behind the practice of evaluation in the field. In addition, the availability of a national CBA guideline does not necessarily translate to a standardized practice within each country. For larger countries such as the United States, wide variations exist in methods, benefits categories, and parameter variation values used by localities and states. In addition, practice and guidelines change over time, so to some extent this review is a snapshot of a changing practice. These are limitations that this research has had to accept.

This paper is structured as follows:

- The second section presents a discussion of strategic differences from a rail assessment perspective in the CBA frameworks identified,
- The third section discusses parameter valuation evidence assembled in the review,
- The fourth section outlines the case study methodology adopted,
- The fifth section discusses the findings of the case study, and
- The sixth section concludes with a summary of key findings.

RESEARCH CONTEXT

The 12 countries or regions included in this comparative assessment were selected on the basis of the following three considerations:

1. The 12 countries or regions have cities that feature highly in the Mercer *Quality of Living Survey* (*12*), *The Economist's World's Most Liveable Cities* (*13*), and Monocle's *Most Liveable Cities Index* (*14*). The rationale was that these renowned surveys have considered public transportation as a criterion in their ranking. It is reasonable to assume that with their good public transportation systems, these countries are likely to have also established a comprehensive assessment framework for their PT investments.
2. The selected countries included affluent Asian countries such as Singapore and South Korea and the region of Hong Kong, China, in view of their high-quality urban rail systems. The rationale was that, given their quality rail system, these countries may have also established a more comprehensive economic appraisal framework.
3. Finally, the selected countries had an availability of published national guidelines or previous research.

Table 1 outlines a comparison of CBA approaches among the 12 countries or regions studied. Key features are now discussed.

Role of CBA

All countries generally adopt a multicriteria analysis (MCA) approach for project evaluation with CBA being one of the key components. Use of CBA varies. Project evaluation is usually supplemented with other specialized studies such as an environmental impact statement. These other factors could be considered separately from the CBA (e.g., an environmental impact assessment, as in the case of Australia) or weighted and summed up in a formal MCA (as in the case of the United Kingdom). The MCA allows decision makers to subjectively assess monetized and nonmonetized impacts. Examples of the tabular summary include the Australian Appraisal Summary Table and the Japanese Benefit Incidence Table.

Components of Financial Cost

All countries include capital, system operating, and maintenance costs in CBA. Most include costs associated with mitigation related to negative impacts of a project. In addition, the U.S. and Australian guidelines further stipulate that the costs of required improvements in other parts of the transport system that result from implementing the new rail proposal should be included as a cost component in CBA.

Only the United States, New Zealand, Germany, and Singapore do not consider the residual value of assets in CBA. The other countries treat residual value as a negative cost in the previous appraisal year to account for the benefits that the proposal can provide beyond the assessment period. Among them, the United Kingdom and the Netherlands further specify a criterion for the inclusion of residual value. Residual values are considered only for projects with finite lives less than 60 and 100 years, respectively, in the English and Dutch guidelines.

Monetized Benefit Components

There is more variation in monetized benefit assessment in the approaches reviewed. Primary and secondary benefits are generally identified. As defined by TRB, primary benefits are directly associated with the activity of travel itself and its effect on users, while secondary benefits are generated over and above the direct benefits that accrue to users of the rail system (*1, 6*).

Primary Benefits

Primary benefits comprise mainly travel time savings (TTS) and reductions in operating and accident costs. All the countries include accident costs resulting from reductions in road travel in their CBA frameworks. However, there is great variation in the unit accident costs adopted. Other benefits can be estimated for four main groups: PT users, automobile users, truck users (or cargo transit users), and pedestrians and cyclists (Table 1).

Public Transport Users

All countries consider TTS and fare savings as a benefit for PT users, who include existing PT users, diverted PT users (whose trips were previously made on another PT service), and former car drivers and passengers. The benefit for existing PT users is usually reflected as a savings in the generalized 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 diverted PT users as well as 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 min per one-way trip. They view that a small TTS is unlikely to be put to 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 except Japan. This benefit is measured largely in terms of TTS as well as a

TABLE 1 Comparison Matrix of International Assessment of Evaluation Approaches to Urban Rail Projects (*1*; *6–11*; *15–31*)

		Country or Region											
Parameter	Details	Australia	New Zealand	United States	Canada	United Kingdom	France	Netherlands	Germany	Japan	South Korea	Hong Kong	Singapore
Cost	Capital costs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Operating and maintenance costs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Costs to mitigate negative effects of project	✓	✓		✓	✓		✓	✓		✓	✓	
	Costs to improve other parts of transport system	✓		✓									✓
	Residual value of asset	✓			✓	✓	✓	✓		✓	✓	✓	
Benefit	PT users												
	Travel time savings	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	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	✓	✓	✓	✓						✓	✓	✓
	Pedestrians and cyclists												
	Travel time savings	✓		✓									
	Vehicle ownership and maintenance cost savings	✓		✓									
	Externalities												
	Air pollution	✓	✓	✓	?		✓	✓	✓	✓	✓		
	Greenhouse gas 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							?					

(continued on next page)

TABLE 1 *(continued)* **Comparison Matrix of International Assessment of Evaluation Approaches to Urban Rail Projects (*1*; *6–11*; *15–31*)**

		Country or Region											
Parameter	Details	Australia	New Zealand	United States	Canada	United Kingdom	France	Netherlands	Germany	Japan	South Korea	Hong Kong	Singapore
Discount rate	Method of derivation												
	Return on private investment		✓	✓	✓					X	✓	✓	
	Time preference					✓				X			✓
	Borrowing rate	✓						✓		X			
	Weighted average approach									X			
	Shadow price of capital approach						✓			X			
	Optimal growth rate approach								✓	X			
	Value adopted	Discount rate nominated by funding body	8%	3% and 7%	10%	2.5%–3.50%	8%	4%	3%	4%	6.5%	Depend on rail operator	4%
Evaluation period (years)		50	30	20	30	60	30	Tied to project lifespan (max. 100)	40	30–50	20–30	30–120	60
Decision criteria	NPV	✓		✓	✓	✓	✓	✓			✓	✓	
	BCR	✓	✓						✓	✓	✓		✓
	IRR						✓	✓			✓	✓	

NOTE: ✓ = approach adopted in guidelines from country; blank = monetized and included; ? = no information or unclear whether subject parameter is included in CBA; X = not monetized; NPV = net present value; BCR = benefit–cost ratio; IRR = internal rate of return.
SOURCE: K. S. Kim, personal communication, 2008; W. L. Lim, personal communication, 2008; S. Zwartjes, personal communication, 2007; A. I. J. M. van der Hoorn, personal communication, 2008.

savings in automobile 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 United States take the view that transit improvements may affect relatively long-run decisions, including the decision to own motor vehicles. Hence savings for vehicle ownership and the subsequent maintenance costs are considered in their CBA approaches.

Truck Users and Freight or Cargo Transit

The United States, New Zealand, Canada, Australia, Hong Kong, and Singapore include TTS and operating cost reductions as well as savings in time-related inventory costs for truck users (or goods vehicles) in CBA. Clearly this parameter is a valid factor when road freight volumes are significant or when the cargoes involved are valuable (*1*). These benefits are estimated explicitly in the U.S., New Zealand, and Canadian guidelines. In the Australian, Hong Kong, and Singapore approaches, freight impacts are estimated from the average resource value of time for goods vehicles, which is an input in the estimation of the TTS for these vehicles.

Pedestrians and Cyclists

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

Secondary Benefits

Secondary benefits are generated over and above the direct benefits that accrue to users of the rail system and largely comprise the positive effect to environmental externalities such as air quality and noise impact (*1*). In addition, several countries also include wider economic benefits such as option value (OV) and agglomeration benefits into CBA.

Environmental Externalities

All countries except Hong Kong and Singapore have evaluated and monetized 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) to be examined as part of their project evaluation. However, these impacts are examined separately from the overall quantitative CBA appraisal. The U.K. guidelines also recommend the assessment of environmental impacts outside the CBA framework.

Impact of Air Pollution and Greenhouse Gas Emissions

Most countries consider the intensity of pollutants including carbon monoxide, particulate matter smaller than 10 μm in diameter, hydrocarbons, and oxides of sulfur 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.

Impact of Noise

Internationally, noise impact is one of the two most common externalities included in CBA. Most countries estimate a monetary value by using a hedonic pricing method approach except Germany, which bases its value on the cost for equipping houses with noiseproof glazing.

Impact of Water Quality and Nature

Water quality and nature impacts are included in CBA approaches in selected countries. Water quality impact is addressed in the U.S. 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.

Only Australia requires the quantification of nature impacts in CBA. New Zealand guidelines assess nature impacts separately from 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 monetize 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.

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" (*32*). Only the United States includes OV in its appraisal framework.

Agglomeration Benefits

The other area of recent international interest is the consideration of wider agglomeration benefits in transport appraisals (*4*). Agglomeration benefits result from the increase in productivity, creativity, and synergy among firms caused by a higher concentration of firms or higher density of employment made possible by more compact, transit-served development (*6, 33*). Only the guidelines of the United Kingdom, New Zealand, Germany, and the Netherlands have incorporated this benefit in their CBA to various extents (Table 1).

According to Keegan et al. (*4*), no significant research has been performed in this area until the recent work of Graham (*34–38*), who suggests that the transport system can influence the proximity between firms and the labor market to a certain extent and can improve urban or industrial densities by rendering a larger scale of activity more accessible. A major transport study that included agglomeration effects was the recent U.K. study by Sir Rod Eddington (*4, 39*). Eddington noted that the agglomeration effect could increase the overall project benefits of transport projects "by up to 50 per cent in some cases" (*39*). Vickerman 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" (*33*). Despite these findings, agglomeration benefits are not included in U.K. 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. A. I. J. M. van der Hoorn (personal communication, 2008) and S. Zwartjes (personal communication, 2007) recommend the inclusion of enhancement to property values for larger Dutch transport projects, such as 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.

Accounting Approaches

Social Discount Rate

Table 1 illustrates a range of approaches to social discount rate (SDR) development. These are real, not nominal rates, that is, they are adjusted for inflation. The most common approach is the marginal rate of return on private-sector investment, which is adopted by the United States, New Zealand, Canada, Hong Kong, and South Korea. This approach yields an SDR of 6% to 10%. Only the United Kingdom stipulates a different SDR for different evaluation periods:

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

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

Assessment Period

The most common evaluation period appears to be 20 to 30 years. The Netherlands and Hong Kong tagged their assessment period to the types of transport projects being evaluated. In these cases evaluations up to 100 years or more can be carried out. The wide variation in the analysis period is interesting and is a potential area of future research.

Decision Criteria

Three decision rules are most commonly employed in CBA:

- Net present value (NPV),
- Benefit–cost ratio (BCR, also known as the profitability index), and
- Internal rate of return (IRR).

NPV is the most common decision criterion. 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, which is equal to the surplus of the first year divided by the cost of the investment, to check the year of implementation of their projects. The optimum year of implementation is when the first-year rate of return is equal to the discount rate.

Most countries require a BCR greater than one. In Germany a BCR value greater than three is adopted. Rothengatter (*11*) points out that this is a result of expected double counting of effects in the German method. He suggested that double counting of effects was deliberately built into the German system to mitigate equity issues among regions.

PARAMETER VALUATIONS

This section examines parameters included in rail CBA approaches in three broad categories: value of time (VOT), accident costs, and values of externalities (Table 2).

To aid comparison, parameter values for each country are converted to 2006 Australian dollars. 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. The parameter values were first updated to 2006 values according to the average wage increment of each country between the date the VOT was captured (as shown in the guidelines) and 2006. The 2006 values were then converted to Australian currency according to the exchange rates provided by the Australian Reserve Bank.

Value of Time

VOT data are for PT users and car drivers for trips to and from work. This time bracket is chosen as it represents the time when passenger ridership and vehicular traffic are the highest in the network and VOT 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 and
- The stated preference or revealed preference approach.

VOT for commuting trips to and from work ranges from about $5 in Australian dollars per hour (A$5/h) (for Singapore and Hong Kong) to A$15/h (for the Netherlands) (Figure 1). This significant discrepancy in VOT can largely be attributed to the different wage rate premiums of each country. The implication is that countries like the Netherlands would value benefits three times more than Singapore for the same project TTS. This implication is significant given the dominant role of TTS in urban rail appraisals.

Most of the countries adopt a similar VOT for PT users and car users. In the United States, for example, VOT for both PT and car users is A$14.01 [based on the average U.S. wage of $10/h (*1*)]. For New Zealand, Hong Kong, and Singapore, a higher VOT is used for car users than for PT users, while the Netherlands adopts a slightly lower VOT for car users. The use of different VOTs for automobile travel and transit travel is interesting and suggests future research. 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. VOT of most countries is about 30% to 50% of the average hourly wage rate.

Accident Costs

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

- The human capital approach and
- The WTP 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 (*16*).

Valuation of mortality accidents is very different among countries (Table 2 and Figure 2). The highest value of a fatal accident is A$6.66 million in the United States; the lowest is A$0.1 million in Singapore. Valuation of serious accidents and minor accidents also varies widely among countries. While each serious accident costs about A$490,000 in the United Kingdom, the value is about eight times lower in Germany at about A$60,000. Likewise, minor accidents are about nine times more costly in the United Kingdom and Canada compared with Germany and Japan. The U.S. approach applies the same value to serious accidents and minor accidents, both of which were valued at $10,000 (2002 values) (*1*).

Externality Costs

Broad average valuations for externality costs are shown in Table 2. Most guidelines suggest 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 notes 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" as a result of the different methods employed as well as the differing principles in the way costs are assessed (*40*). This challenge is clearly evident from Table 2, which shows that 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/vehicle km in the United States, but the Australian guidelines estimate a value of A$0.0080/vehicle kilometer, which is about five times higher. Australia, New Zealand, and the Netherlands have a unified cost value for air pollution, but the United States uses a different monetary value for each air pollutant.

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, Australia. 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. The project is expected to benefit some 2,000 rail users and 2,500 automobile users daily. All CBA approaches are applied to the case study excluding those from the South Korea, where no parameter value information was available. In summary, the case study was prepared using the following steps:

- CBA for each country is applied according to 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. The costs of each country were converted to the 2006 value of their respective currencies by using wage trends from the relevant national authorities. These were then converted to Australian dollars by using the 2006 exchange rates from the Australian Reserve Bank.
- Capital and operating costs of the hypothetical rail project are assumed to be the same for all 12 countries. (While countries with lower VOT will also have lower labor costs, there is insufficient data for this study to work out how the project costs may vary among countries. This research therefore made the above assumption to facilitate the study. This estimate is envisaged to yield a conservative result since the project costs may be on the high side for countries with lower labor costs.)
- Vehicle operating cost (VOC) values in the guidelines of Australia, New Zealand, the United States, the United Kingdom, Canada, and the Netherlands range between A$0.14/km and A$0.18/km for passenger cars commuting to and from work. An average VOC of A$0.16/km is adopted for countries lacking published VOC values.
- 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 United States, which includes OVs in its CBA, an OV benefit is estimated on the basis of information provided by TRB (*1*).
- For the United Kingdom, New Zealand, the Netherlands, and Germany, which incorporate agglomeration effects in their CBAs, an agglomeration benefit is benchmarked at 50% of the direct transport benefits as suggested by Eddington (*39*) and Vickerman (*33*).
- An SDR of 6% and 10% is assumed for the Australian and Hong Kong appraisals, respectively. This assumption is based on the 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 for which parameter values were not available, the corresponding Australian values were adopted.

RESULTS AND DISCUSSION

Table 3 shows the resulting CBA assessments obtained by using the above approach. Very different evaluation outcomes emerge. Only the Australian, U.S., U.K., and Dutch approaches found the proposal economically feasible. Although Germany achieved a BCR of 1.31, the proposal was not economically feasible as their decision criteria require a project to have a minimum BCR of three before it will be considered for implementation.

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

Value of Time

TTS contributes about 50% to 60% of the total benefits generated by the project. On this basis appraisal outcomes can be very sensitive

TABLE 2 Comparison of Parameter Values for 2002 (*1*; *6–11*; *15–31*)

	Country or Region					
Parameter	Australia	New Zealand	United States	Canada	United Kingdom	France
VOT Commuting to and from Work						
PT users (A$/h)	10	6.42	14.01	9.56	12.10	11.41
Car users (A$/h)	10	7.59	14.01	9.56	12.10	411.41
Accident Costs						
Fatal accident (A$ millions)	1.85	2.99	6.66	2.39	4.25	1.24
Serious accident (A$)	454,230	320,970	382,950	132,827	487,535	127,840
Slight accident (A$)	14,014	18,723	13,320	50,313	49,677	27,179
Externalities						
Air pollution	A$0.0252/vkm	A$0.0089/vkm	A$0.02/kg CO to A$20.40/kg PM10	X	Θ	A$0.0268/ pax km
Greenhouse gas emission	A$0.0031/vkm	7.5% of VOC	Θ			A$0.0081/ pax km
Water quality impact	A$0.0038/vkm	Θ	A$0.0005/vkm			Θ
Noise impact	A$0.0080/vkm	A$365.55/db/ household/ year	A$0.0015/vkm		A$24.38 to A$284.40/db/ household/ year	X
Nature and landscape	A$0.0034/vkm	Θ	Θ		Θ	Θ

NOTE: X = no information; vkm = vehicle kilometer; Θ = not assessed; CO = carbon monoxide; PM = particulate matter; db = decibel; pax km = passenger kilometer.
SOURCE: K. S. Kim, personal communication, 2008; W. L. Lim, personal communication, 2008; S. Zwartjes, personal communication, 2007; A. I. J. M. van der Hoorn, personal communication, 2008.

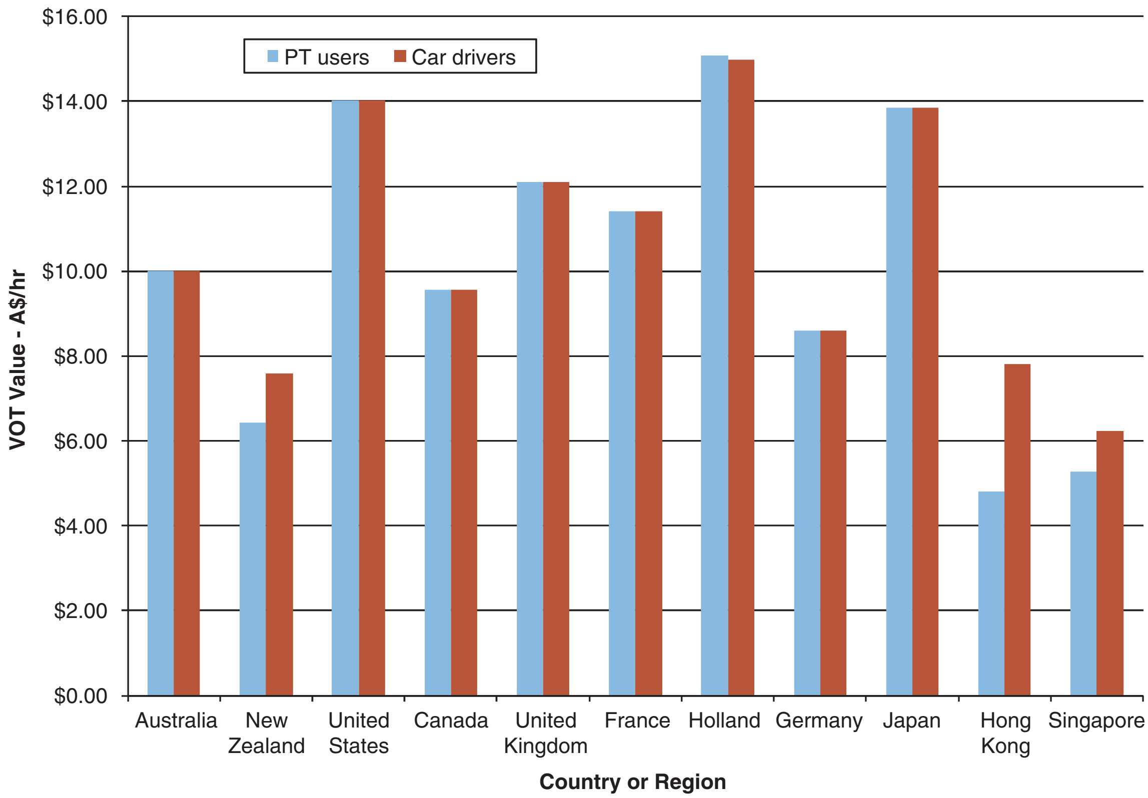

FIGURE 1 Standardized value of time results for car and PT users.

Netherlands	Germany	Japan	South Korea	Hong Kong	Singapore
15.07	8.59	13.85	X	4.81	5.27
14.97	8.59	13.85		7.81	6.26
1.55	1.33	0.32	X	X	70,000–100,000
206,464	60,663	96,866			
30,970	5,257	6,183			
A$0.0134/vkm	X	A$5,977/ton nitrogen oxide	X	Θ	Θ
A$0.0103/vkm	Θ	A$24/ton carbon	X		
X	Θ	Θ	Θ		
A$0.0052/vkm	X	A$4,897/db/km/year	X		
X	Θ	Θ	Θ		

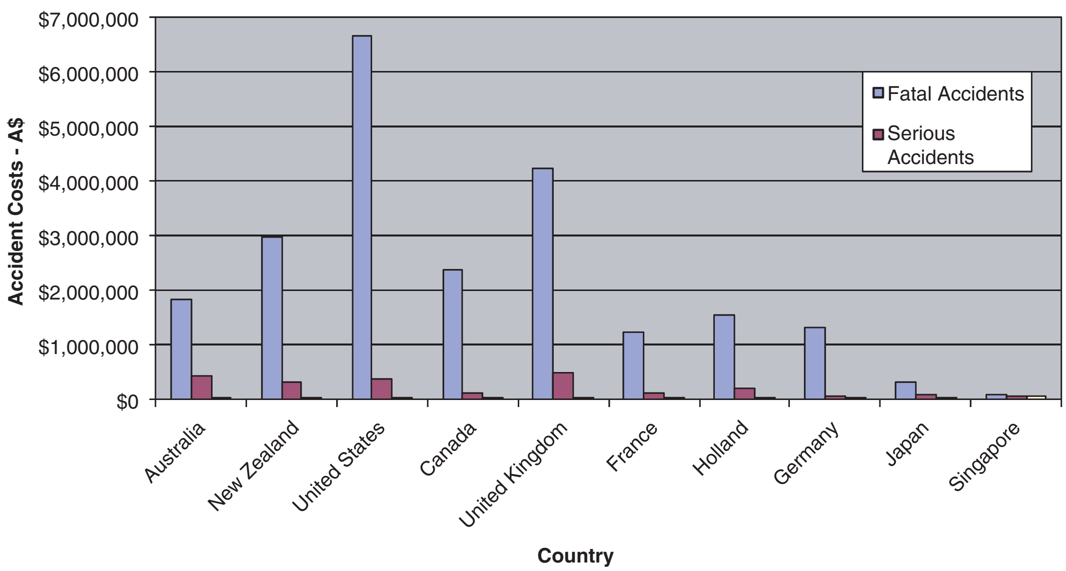

FIGURE 2 Standardized value of accident costs.

TABLE 3 Evaluation Results of Case Study

Detail	Country or Region: Australia	New Zealand	United States	Canada	United Kingdom	France
SDR used in case study (%)	(assumed) 4	10	3 and 7	10	2.5–3.5	8
Evaluation period (years)	50	25	20	30	60	30
Evaluation results						
NPV (A$ millions)	112	–27,233	5,927	–40,583	130,836	–9,912
BCR	1.00	0.69	1.07	0.51	2.09	0.90
IRR (%)						5.50
Evaluation outcome	✓	—	✓	—	✓	—

NOTE: ✓ = passed economic appraisal; — = criteria not defined.

to changes in VOT. For example, if the VOT used in the U.S. assessment is increased by merely \$0.10/h, the project would be economically feasible with a BCR above unity. Clearly it is important that VOT estimates are updated periodically to ensure that benefits are accurately assessed against costs.

Relief for Congestion

Most countries included road user TTS and vehicle operating costs when estimating congestion relief (*16, 22*). Congestion relief accounted for about 40% to 50% of total project benefits. Japan does not include congestion relief benefits. This is a major omission since its BCR would improve significantly from about 0.48 to 0.55 to about 1.21 to 1.41 if congestion relief were included in its assessment.

Accident Costs

Accident cost savings contributed no more than 3% of the total project benefits for most countries. For countries such as Singapore and Japan, where accident cost unit values are comparatively low, BCRs would improve if a higher accident cost value were adopted.

Environmental Externalities

The inclusion or omission of environmental externalities in CBA was not a significant factor in the outcome of the rail case study, an observation consistent with the views of TRB (*1*). Environmental benefits in the case study accounted for about 4% or less of the total project benefits.

Option Value

OV benefits in the U.S. CBA were estimated for scenarios in which car users were willing to buy the options to use the rail alternative two to 10 times a year according to estimates from TRB (*1*). For all scenarios, OV benefits accounted 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. Laird et al. note that "the field of measuring transport option values clearly is far from developed" (*32*), and further research in this area is warranted.

Agglomeration Benefits

Agglomeration benefits are included in the Dutch and German CBA analyses. Results suggest that these benefits could account for as much as 30% of total project benefits. If they were included in the CBA approaches for all countries, the appraisal outcomes would improve significantly. Given the lack of research in this area (*4*) and the potential significance of its contribution to the economic viability of transport proposals, further research into the validity of agglomeration benefits is indeed important.

Social Discount Rate and Assessment Period

Sensitivity analysis was performed by using discount rates between 4% and 10%, and the CBA framework of Hong Kong was used as an example to analyze the impact of the assessment period on the CBA of rail initiatives. Sensitivity analysis results indicate that lower SDR values will result in higher NPV values (Figure 1). The analysis further suggests that it may be more appropriate to use an SDR of 4% or higher to appraise the feasibility of individual rail projects, as an SDR lower than 4% is likely to always yield a positive NPV for conventional CBA.

The analysis results suggest that it is preferable to keep the evaluation period of rail projects to within 60 years as NPV does not fluctuate much after 60 years. This is especially the case for higher SDR values (Figure 3). However, the case study also suggests that an assessment period less than 30 years may be too short for rail investment appraisal as the benefits accrued over 30 years do not act to cover the substantial rail project costs incurred earlier in the project's life.

CONCLUSIONS

This paper compares CBA approaches to urban rail project evaluation in Australia, the United States, the United Kingdom, Canada, New Zealand, Germany, the Netherlands, France, Japan, Hong Kong, South Korea, and Singapore. An assessment of strategic frameworks and individual parameter valuations was undertaken. A case study evaluation illustrates the impacts of differences in CBA approaches.

Strategically, all countries adopt an 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

Netherlands	Germany	Japan	South Korea	Hong Kong	Singapore
4	3	4	6.5	(assumed) 10	4
(assumed) 50	40	30–50	20–30	30–120	60
180,850		−53,987	Not evaluated	−60,155	−65,771
2.61	1.31	0.48–0.55		0.27	0.43
15.50				5	
✓	—	—	—	—	—

consider capital, operating, and maintenance costs in their CBAs. Some also include the residual value of the assets in their assessment.

There is noticeably more variation in approaches to monetized benefits. TTS is a common primary benefit. Japan does not include congestion relief in its CBA. Several countries, including Australia, also capture TTS for truck users as well as pedestrians and cyclists in their assessments. Another common benefit included in CBA internationally is accident cost savings. However, there is much variation in the unit accident costs adopted. The use of sensitivity analysis of parameter values in the evaluation would enable a more robust set of analyses when input values vary between countries.

In terms of secondary benefits, all countries and regions except Hong Kong and Singapore include the impact to environmental externalities to various extents in their CBAs. Air pollution and noise impact are the most common environmental externalities considered. The United States is the only country that includes OV in its CBA, and only Germany and the Netherlands adopt agglomeration benefits in their economic appraisals.

There are considerable variations in SDR, the assessment period, and the decision criteria adopted. Most countries derive SDR on the basis of the marginal rate of return on private-sector investment, which yields an SDR of 6% to 10%. The most common evaluation period is 20 to 30 years. NPV is the most common decision criterion among the approaches examined.

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

To illustrate the implications of these strategic and tactical differences, a case study was developed that found very different evaluation outcomes according to the approaches adopted. Only the approaches in Australia, the United States, the United Kingdom, and the Netherlands found the proposal economically feasible (BCR between 1.00 and 2.61). The most important benefits identified from this analysis were TTS and congestion relief, which contributed about 50% to 60%

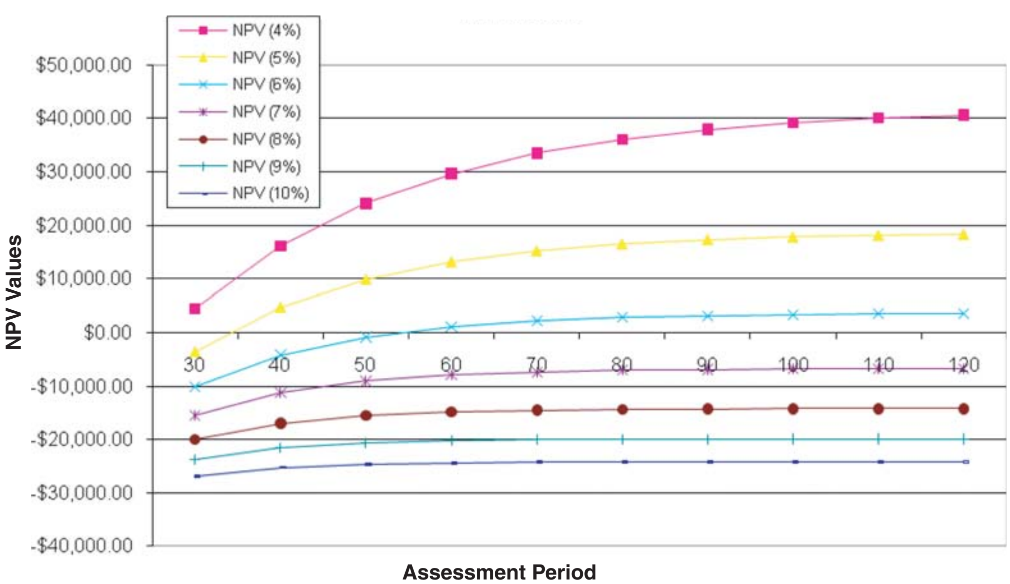

FIGURE 3 NPV trends for Hong Kong across different SDRs and assessment periods.

and 40% to 50% of total project benefits, respectively. Accident cost savings contributed no more than 3% of total project benefits, and the results of the case study suggest that the impact of environmental externalities in CBA is not significant.

The case study analysis suggests that OV benefits accounted for no more than 1% of total project benefits in the U.S. appraisal. However, it is acknowledged that OV is a relatively new area in transport economics, and 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 they were included in CBA approaches.

Sensitivity analysis suggests that an SDR of 4% or higher should be used to assess the economic feasibility of individual rail proposals, and 30 to 60 years appears to be the most common assessment period for rail investment projects.

So what do the findings say about international approaches to CBA in urban rail? The diversity of approaches clearly reflects differing views of what methods are appropriate in different geographies. This might be because of specific conditions in some locations; for example, OVs may not be considered important in one location but important in others. Another example is the diversity of accident costs: it may well be that fatality cost assessments vary because of different views on the value of life in different locations. However, some of the findings seem hard to interpret from this perspective. Neither Hong Kong nor Singapore includes environmental externalities, and Japan does not include congestion relief benefits. It seems unlikely that such factors are unimportant in high-density cities with urban pollution and endemic traffic congestion. The use of rail in each of these Asian locations is likely to be fundamental to addressing environmental and congestion relief issues, yet authorities in these contexts do not consider these issues important to rail appraisal.

Another possible explanation for diversity in approaches is the lack of uptake or understanding of new approaches to CBA appraisal methods. Conservatism in approaches to evaluation, especially a preference for historical and conventional methods to new, untried, and possibly speculative methods, is another explanation. This can be a common feature of national treasuries seeking balanced approaches to fiscal management.

The variation in CBA approaches can suggest possible improvements, particularly in cases in which countries have chosen to adopt different kinds of benefits. The obvious examples are those counties not using certain kinds of benefits, such as environmental and congestion relief. Unusual parameter values can also point to the need for changes in approach. When values adopted are unusual compared with international practice there is a need to understand why this is the case. These are all promising outcomes from the comparative assessments performed in this study.

To some extent CBA approaches do not have to conform to any international standards when being applied to project appraisal for local funds. All local projects being compared have the same local approach, and results are technically comparable. Only when methods are compared between countries do differences exist. While this is undoubtedly true, capital for many major rail projects is often sourced from international financial institutions. Moreover, international companies are often involved in construction and operations, so there is at least some rationale for comparable CBA approaches on an international basis.

When rail projects are compared with road projects and projects from other sectors, both what is included and excluded in the evaluation may be significant to the final CBA. Agglomeration benefits, for example, are important to rail in the Netherlands and would considerably boost the net benefits of rail projects there. Countries or regions that don't include these benefits run the risk of undervaluing rail projects. Similarly, rail projects evaluated in Hong Kong and Singapore without consideration of environmental benefits or Japanese rail projects, which omit congestion relief benefits, may suffer an adverse CBA.

The variation in approaches is also an important consideration for the profession and discipline of economics. It seems unlikely that the methodological diversity demonstrated in this paper can all be based on a logical assessment of differences in local conditions. There seems to be a role for economists to encourage more standardization of approaches among countries. Methods that adjust for variation in values adopted (such as sensitivity analysis) should be encouraged to ensure a more robust analysis. Disagreement about new areas of economic benefits such as agglomeration economies strongly suggest the need for research to clarify the viability of these considerations and to develop methods that are both robust and easy to apply in measuring benefits of this kind. There is also a role for research to explore the rationale behind the adoption of CBA approaches in different countries. In this way variations in approaches to CBA in urban rail might rest on a defendable knowledge base that might also identify areas in which additional research in CBA methods are required.

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