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Why do major public transport projects struggle to justify their economic benefits?

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Abstract

Transport projects proposed by government agencies are required to undertake an economic appraisal to justify the economic viability of the proposed projects. Increasingly, many major public transport projects struggle to justify their economic cases. The economic benefits of major public transport projects are broadly categorised into conventional transport benefits, land use benefits and wider economic benefits. This paper provides a detailed review of the methodology underpinning the economic appraisals, as well as identification of the key challenges associated with justifying public transport's economic benefits. Some recommendations in relation to the economic benefits of public transport project are provided for practitioners' consideration.

1. Introduction

Promoting public transport is a common goal of many government agencies. Public transport not only provides improved accessibility but also creates a wide range of benefits to the society. However, as resource and budget are constrained, government agencies are required to justify and prioritise investment in public transport to ensure the resource is allocated efficiently.

A business case is usually required for agencies to apply for government funding, which details the need for investment, options development, economic justification and delivery plan. Of all the components of a business case, agencies often face the challenge of justifying the economic benefits of a public transport project compared to its high whole-of-life cost.

Economic appraisals of public transport projects in Australia are undertaken in accordance with national guidelines (i.e. Australian Transport Assessment and Planning) and State-specific guidelines. These guidelines set out the appraisal framework, methodology and parameter values to be applied in economic appraisals. The provision of these guidelines ensures the consistency and robustness of economic appraisals adopted by practitioners.

This paper reviews a number of public transport economic appraisals that are publicly available. These selected projects reportedly have a relatively low benefit-cost-ratio (BCR). Following the review, this paper analyses the key issues associated with the justification of the economic benefits of public transport with references to existing economic appraisal guidelines and international research. For the issues identified, this paper provides further insight and suggestion for practitioners who encounter similar challenges.

2. Review of public transport appraisals

The economic justification of a transport investment is typically appraised using a cost benefit analysis (CBA). The relative benefits to costs of a project, typically measured by a BCR, provide an indication as to whether the project is expected to generate net economic benefits to the society.

The economic benefits generated by a transport project could be broadly categorised into transport benefits, land use benefits and wider economic benefits as summarised in Table 1.

Table 1: Broader categories of economic benefits generated by public transport infrastructure

Category	Description	Benefits
Transport benefits	Net benefits to society (social surplus) arising from the investment of transport infrastructure, including benefits to consumers, producers and externalities.	• Travel time savings • Vehicle operating cost savings • Improved reliability • Improved amenity • Decongestion • External cost savings • Crash cost savings • Others
Land use benefits	Benefits arising from change in land use (i.e. relocation of employment and population) dependent on the proposed transport infrastructure.	• Urban consolidation resource savings • Urban consolidation transport benefits • Gains from housing or business location
Wider economic benefits	Benefits transmitted into the wider economy due to distortions or market failures.	• Agglomeration benefits • Increased labour supply • Imperfect competition

Transport benefits are made up of changes in consumer surplus, producer surplus and externalities (Infrastructure Australia, 2017a). These are sometimes referred as “conventional transport benefits” as there has been an established methodology and guidelines developed for practitioners.

In addition to transport outcomes, transport projects can sometimes lead to land use outcomes, especially for major public transport infrastructure. Theory has suggested that population and employment could relocate in response to improved accessibility (Pagliara et al., 2002; Schirmer et al., 2014; Ho and Hensher, 2016). The change in land use may generate additional economic benefits that are not captured in conventional transport benefits. Land use benefits generated by transport infrastructure are broadly recognised in Infrastructure Australia (2017a).

The third stream of benefit is wider economic benefits. Under a perfect market condition, transport benefits would capture the entire welfare effects of a transport project. However, the market is usually imperfect which means the economy is not functioning efficiently. As a result, additional benefits may arise from a transport project which are not captured in the conventional transport benefits. These benefits are usually represented by improved business productivity (i.e. agglomeration) from improved accessibility, and benefits arising from relocation of businesses and households (UK Department for Transport, 2016).

This paper reviews a number of major public transport economic appraisals that are publicly available. As discussed above, the BCR is a key indicator of the economic viability of a transport project. In the context of Australia, it is a standard practice to present BCRs with and without wider economic benefits as required by Infrastructure Australia and most State guidelines. Some economic appraisals have also attempted to quantify the land use impact for inclusion in the appraisal.

Table 2 shows the BCRs of selected public transport projects over the past five years. It can be seen that these selected projects have an estimated BCR between 0.5 to 1.5 when only considering transport benefits. Inclusion of land use benefits and wider economic benefits (including agglomeration benefits) would increase the economic benefits but still below 2.0.

Table 2: Estimated economic viability of selected public transport projects (based on a real discount rate of 7%)

Project	BCR – transport benefits only	BCR – transport + land use benefits	BCR – transport + land use+ wider economic benefits
ACT Capital Metro[1]	0.5	1.0	1.2
VIC Melbourne Metro (Metro Tunnel)[2]	1.1	Not specified	1.5
NSW Sydney Metro City & Southwest[3]	1.3	1.3	1.7
NSW Sydney Metro City & Southwest[3]	1.47~1.6 (detailed breakdown not specified in the business case summary)		
WA Forrestfield-Airport Link[4]	1.4	Not available	Not available
NZ Auckland City Centre Rail Link[5]	<1.0	<1.0	<1.0
Australia East Coast High Speed Rail[6]	1.1	Not estimated	Not estimated

Source:
[1]Capital Metro Agency 2014, *Capital Metro – Full Business Case*, ACT Government, October 2014, p. 89, available at: http://www.actlightrail.info/p/capital-metro-business-case-oct-2014.html
[2]Melbourne Metro Rail Authority 2014, *Melbourne Metro Business Case – Appendix 6 Economic Evaluation*, Victorian Government, February 2016 p. 43, available at: http://metrotunnel.vic.gov.au/library/business-case
[3] Infrastructure Australia 2017b, Infrastructure Australia Project Business Case Evaluation: Sydney Metro City & Southwest, June 2017, available at http://infrastructureaustralia.gov.au/projects/files/Sydney_Metro_City_Southwest_Summary.pdf
[4]Infrastructure Australia 2016a, *Infrastructure Australia Project Business Case Evaluation: Forrestfield-Airport Link* , September 2016, available at: http://infrastructureaustralia.gov.au/projects/files/WA-Forrestfield-Airport-Link.pdf
[5]Auckland City Centre Rail Link 2011, Auckland City Centre Rail Link Business Case Review, May 2011, p.7, available at: http://www.transport.govt.nz/assets/Import/Documents/City-Centre-Rail-Link-Review-final-report.pdf
[6]Department of Infrastructure and Regional Development 2011, High Speed Rail Study Phase 2 Report, 2011, p.31, available at: https://infrastructure.gov.au/rail/trains/high_speed/index.aspx

Most of these projects are considered as major infrastructure investments in Australian capital cities which aim to increase public transport usage by providing frequent and reliable services. However, the economic case for these projects are not as strong as road projects. For example, the WestConnex project in NSW, although with a total cost of around $17 billion, has a stated BCR of 1.7 on transport benefits alone (Infrastructure Australia, 2016b). Moreover, most highway upgrades would usually generate a BCR of over 2.0 such as Bruce Highway Upgrades (Infrastructure Australia, 2016c, 2017c, 2017d).

Whilst most government agencies are encouraging more public transport use, the economic justification of public transport projects appear to be a challenge to the project proponents. The next section identifies a number of issues associated with appraising public transport projects from a practitioner's point of view.

3. Identification of key issues

3.1 Value of travel time savings

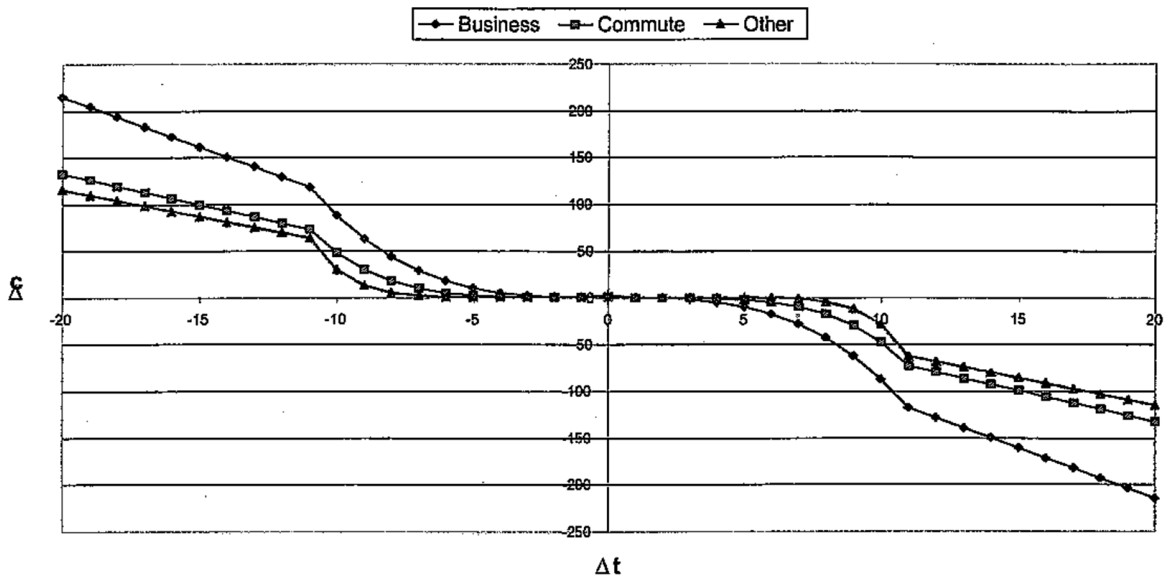
The valuation of travel time savings has been an important task in transport economic appraisal. Mackie et al. (2001) pointed out that travel time savings have accounted for around 81 per cent of the monetised benefits of major road schemes.

Research has suggested that value of travel time tends to be lower for public transport users than car users, as value of time is derived from wage rate or individuals' willingness to pay (Transport for NSW, 2016). However, in most countries including Australia, New Zealand and the UK, an "equity approach" is adopted which standardises the value of time across all modes and all user groups. This approach is commonly accepted to avoid resource allocation favouring higher income users and road projects. This implies that practitioners are already placing a higher value on public transport users than what the theory suggests.

If the unit value of time is not understated for public transport users, it would be worth investigating other factors driving the travel time saving benefits. For economic appraisals, it is a standard practice to assume a constant value of time, which means the unit value of travel time remains constant regardless of the size of the time savings. The implication of this assumption is that a one-minute saving for 1,000 car users is equivalent to a 10-minute saving for 100 public transport users.

There has been research (Bureau of Transport Economics, 1982) suggesting that "small time savings" may not be fully perceived by users or utilised for other economic activities. In fact, the utility of travel time savings perceived by users may not be constant. Figure 1 illustrates the relationship between the perceived utility and travel time savings. It shows that the utility gained increases with the size of time savings. For travel time savings less than five minutes, the utility gained is close to zero.

Figure 1: Perceived utility versus travel time savings



Source: Mackie et al. (2003)

Despite of this evidence, Mackie et al. (2003) suggested that this result could be affected by the way in which the stated preference survey was designed and responded. They also noted that it is difficult to incorporate non-constant value of time in a strategic transport model due to its complexity.

Nevertheless, the diagram indicates that a small time saving based on a constant unit value of time could lead to significant benefit when the travel demand is high. This explains the reason why road projects typically generate higher travel time saving benefits as the car demand is typically substantially higher than public transport demand in the context of Australia and New Zealand.

This issue would become more substantial when the proposed public transport project aims to provide new services to an area where there are limited existing public transport users. Under this circumstance, the change in public transport travel cost must be significantly reduced for people to switch their travel mode from car to public transport. Even if they do switch mode, their changes in consumer plus would need to apply a “rule of half” as explained in the next section.

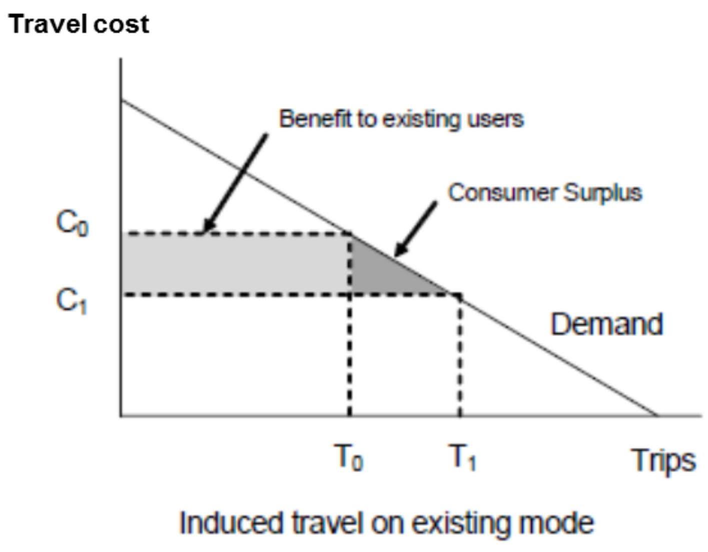
3.2 Benefits of mode shift

Most major public transport projects aim to encourage mode shift from private vehicles. This travel behaviour change can be captured by a strategic transport model. In a strategic transport model, mode choice is predominately determined by comparing the “generalised travel cost” between modes, which is made up of travel time and perceived monetary cost.

Therefore, for an individual to change mode from car to public transport, the generalised travel cost of public transport for a trip needs to be lower than car. This appears to be a challenge as the generalised travel cost does not only include in-vehicle time but also access, waiting and transfer time which collectively make public transport less attractive in a strategic transport model.

Even if the new public transport project does significantly reduce generalised travel cost and attract trips diverted from private vehicles, a “rule of half” would need to be applied to the benefits perceived by these “new users”. The concept of rule of half is illustrated in Figure 2.

Figure 2: Role of half for diverted/induced trips on existing mode



Source: TfNSW (2016)

For new users, either induced from the new transport project or diverted from other modes, their benefit (i.e. consumer surplus) is calculated as:

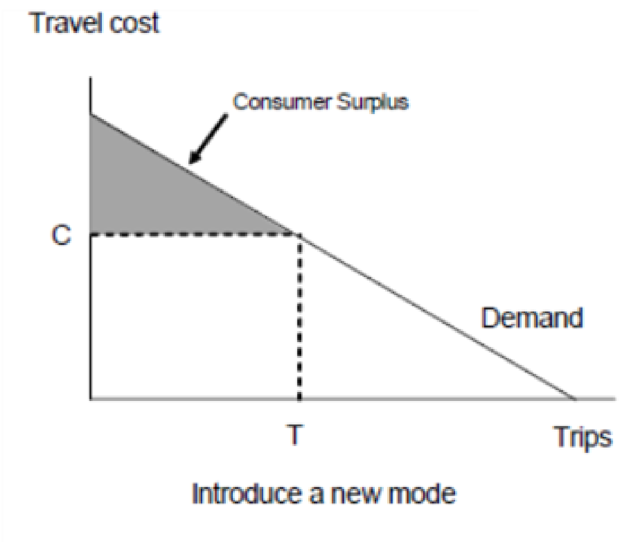
$$Consumer\ Surplus\ of\ new\ users = 0.5 * (T1 - T0) * (C0 - C1)$$

The rule of half is applied to new users because it is unable to determine at which level of generalised travel cost reduction a traveller might have decided to change travel mode. Therefore, some new users may perceive the full benefits in terms of the difference between the generalised travel cost between the base case and project case, whereas some new users may only perceive a proportion of the total benefits. Assuming a linear demand curve, the average benefit is half of the total reduction in generalised travel cost.

The rule of half implies that the benefits enjoyed by those who divert from car to public transport would not be as substantial as benefits to continuing users, as it is difficult to determine the actual benefits perceived by mode switchers.

The other complexity associated with the rule of half is the determination of change in travel cost for a new mode. If a public transport project (e.g. a rail link) represents a new mode in an area, the travel cost in the base case would be undefined and hence the rule of half fails. as shown in Figure 3. This issue is acknowledged in UK Department for Transport (2017).

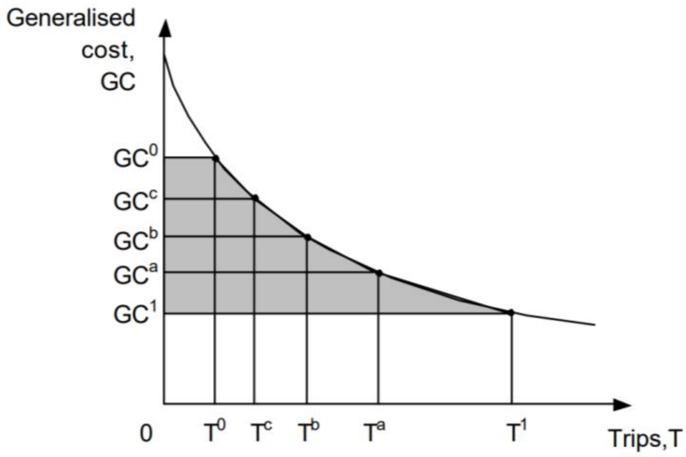
Figure 3: Role of half for diverted/induced trips on a new mode



Source: TfNSW (2016)

Nellthorp and Hyman (2001) proposed to use a numerical integration approach which involves defining a set of trapeziums which together approximate the change in consumer surplus as shown in Figure 4.

Figure 4: Numerical integration for new mode



Source: Nellthorp and Hyman (2001)

Undertaking a numerical integration could be time and resource consuming and hence may not be practical for practitioners. An alternative approach is to use the generalised travel cost of the alternative travel mode as the base case.

The above discussion suggests that the benefits associated with change in generalised travel cost perceived by mode switchers may not be substantial. However, generalised travel cost specified in the strategic transport model may not fully represent all factors that would influence an individual's travel decision. The next section discusses some benefits to mode switchers that are not captured in the generalised travel cost.

3.3 Reliability

One of the key features of public transport projects is improved journey time reliability. This is especially the case for rail, light rail and bus rapid transit projects which have dedicated right of way.

Travellers may choose to switch from car to public transport during peak hours to avoid congestion which causes unexpected delay. However, journey reliability is not explicitly defined in the utility function in a strategic transport model. Instead, it is wrapped up in the "alternate specific constant" which captures travellers' general perception against a specific mode of travel. This means that changes in travel cost would not capture the benefit associated with improved reliability.

The estimation of reliability benefits requires the information of journey time variability in the base case and project case. For rail projects, it is possible to undertake simulation modelling to estimate the standard deviation of journey time between an origin-destination pair. However, this would only allow practitioners to capture the reliability benefits to continuing rail users. For travellers who switch from car or bus, it is challenging to estimate their average lateness in the absence of relevant data.

Transport for NSW (p. 133, 2016) recommended an approach to the estimation of journey reliability by establishing a statistical relationship between travel time variability and volume to capacity ratio (V/C ratio). This approach allows practitioners to estimate road reliability without undertaking a microsimulation modelling. For bus reliability which could be an important issue in the context of a congested corridor, it would typically require historical on time running data to inform the analysis.

3.4 Land use benefit

Public transport projects sometimes are not only designed to improve transport accessibility but also to unlock land use development through the creation of walkable, pedestrian-oriented, high density and mixed-use communities centred around public transport stations.

The land use benefits associated with public transport projects are recognised by Infrastructure Australia (2017a) as summarised in Table 3.

Table 3: Description of land use benefits

Benefit	Description	Note
Urban consolidation resource savings	The lower cost of providing infrastructure services such as water, electricity and gas to denser urban environments.	• Lack of local data and parameter values to determine infrastructure cost • Consideration of both costs and benefits associated with higher density development.
Urban consolidation transport benefits	External cost savings (pollution, crash costs, etc.) as a result of households making more use of walking, cycling and public transport.	• A robust estimation of household relocation is required • Additional demand modelling is required.
Gains from housing or business location	• Perceived benefits for household or business that choose to relocate in response to the project • Land value uplift from increased land use density unlocked by the transport project	• Rule of half • Additional model run • Double counting of travel time saving

The estimation of above land use benefits is associated with some challenges. The urban consolidation resource savings would require local data and parameter values to determine infrastructure cost savings. The other aspect is the determination of the "substitution rate" of infield development in place of greenfield development. Practitioners usually need to undertake desktop research to develop high-level assumptions to estimate this benefit.

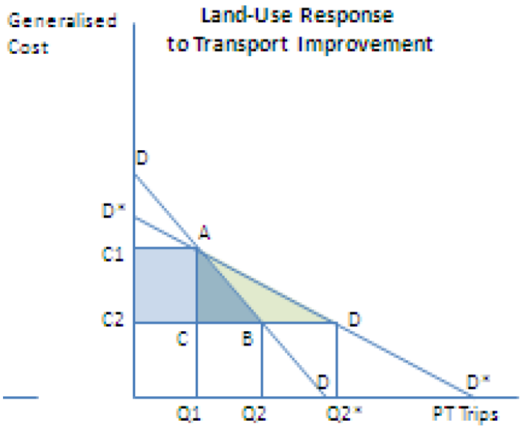
With regard to urban consolidation transport benefits, while the theory is sound and understandable, it is actually challenging to determine how many people would relocate in response to a transport project. Two approaches have been usually adopted by practitioners:

1. Undertaking integrated land use and transport modelling (LUTI) – project population and employment redistribution resulting from changes in generalised travel cost (forecast by strategic transport modelling) by establishing a statistical relationship between land use and generalised travel cost.
2. Determining planning outcomes – assess land use zoning to project potential housing and jobs unlocked by transport projects.

Undertaking LUTI modelling would be an ideal approach but it is costly and it requires a robust model developed for the local context. In contrast, the planning approach is easier to implement but the determination of the planning outcomes could be over or understated in the absence of a robust analysis.

The "gains from housing or business location" is perhaps the most significant but also the most complex one. First, it would share the same issue with the urban consolidation transport benefits in terms of the determination of the level of land use change. Second, it is difficult to determine the benefits perceived by those who relocate. Douglas and O'Keeffe (2016) presented a diagram showing the perceived benefits from transport improvement and land use change in Figure 5.

Figure 5: Perceived benefits from transport improvement and land use change



Source: Douglas and O'Keeffe (2016)

When a transport project reduces the generalised travel cost from C1 to C2, the perceived benefit would be equal to(C1-C2)(Q1) to continuing users plus ½(C1-C2)(Q2-Q1) to new users. With land use change in response to transport improvement, the benefit to those who relocate would be represented by the triangular area ABD. However, there has been no clear guidance on how the perceived benefits of land use change should be estimated. Infrastructure Australia (2017a) suggests a rule of half be applied to the perceived benefits but the steps required to estimate the benefits have yet been specified.

The other component of "gains from housing or business location" is land value uplift arising from land use change in response to a transport project. A number of conditions need to be met to avoid double counting or overstating of the benefit. First, the UK Department for Transport (2015) states that the value uplift can only be included in a transport appraisal for development dependent on the transport investment. Second, the value uplift should only reflect the "planning gains" associated with the development. The impact of improved accessibility on value uplift should not be included to avoid double counting with transport benefits. This is recognised in Infrastructure Australia (2017a) and Transport for NSW (2016).

Determining the expected value uplift from "planning gains", such as increased density, would require a hedonic pricing model. The model also needs to be location specific to reflect the relationship between land value and planning gains from an integrated transport and planning project.

In summary, the existence of land use benefits arising from public transport projects is undebatable. The next steps for practitioners is to develop a consistent approach that can be applied in economic appraisals. A step by step instruction for each component of land use benefits would be beneficial to the industry.

4. Conclusions

CBA is a well-established tool for appraising transport infrastructure projects. Historically, conventional transport benefits have been the focus of economic appraisals. It is true the increased consumer surplus, in terms of travel time savings and vehicle operating cost savings, is the main objective of a transport project. However, a transport project can provide the society with a broader impact which is not captured in the conventional transport benefits.

This is particularly the case for major public transport projects. The value of major public transport projects has been primarily appraised based on travel time savings, decongestion and environmental benefits. The reality is that these benefits usually are not as significant as time savings achieved by road projects, partly due to the “rule of half” applied to mode switchers and partly due to the data limitation to capture some impacts such as reliability benefits.

On the other hand, compared to road projects, public transport could provide more opportunities of achieving land use outcomes. These outcomes can be reflected in increased land value, infrastructure cost savings and even a better transport outcome. Increasingly there are more projects which attempt to capture these outcomes in transport appraisals. However, there needs to be a detailed, consistent and authoritative guidance on the methodology to be adopted nationally. This should include a detailed step-by-step instruction to ensure projects can be appraised on the same ground.

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