

Recognising the complementary contributions of cost benefit analysis and economic impact analysis to an understanding of the worth of public transport investment: A case study of bus rapid transit in Sydney, Australia

Glen Weisbrod^{a*}, Corinne Mulley^b and David Hensher^b

^a *Economic Development Research Group, Inc., 155 Federal Street, 6th Floor, Boston, MA 02110, USA*

^b *Institute of Transport and Logistics Studies, The University of Sydney Business School, NSW 2006, Australia*

*Corresponding author: +1 617 33 6775, gweisbrod@edrgroup.com

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ABSTRACT

With competing demands for scarce resources, governments need to demonstrate the value for money of new infrastructures. The traditional way of demonstrating the value of using public funds is the welfare approach embedded in Cost Benefit Analysis (CBA). In addition to including the tangible costs and benefits for users, CBA can capture the benefits and costs of externalities as well as some of the wider economic benefits. However, this welfare approach does not distinguish the distribution of activity impacts in terms of spatial locations, timing, or economic sectors, nor does it capture all impacts on the economy of a region. Economic Impact Analysis (EIA) can show such changes in terms of jobs, compensation and business output. These types of economic impact changes are very much the language used by politicians in explaining the benefits of an investment and making the points better understood by the electorate. This paper provides the rationale for using an extended analysis EIA as a complement to the welfare based CBA, providing a different perspective for viewing the consequences if investment in public transport. The approach is illustrated by a case study of a bus rapid transit (BRT) proposal in Sydney. It shows how these approaches are complementary, answers different questions, and can be used together to provide a more holistic evaluation of the value of a public transport infrastructure change.

1. Introduction

Public transport investment projects are typically long-lived, high cost and have a long lead time from the start of building to the time of operation when the benefits of the investment begin to be realised. This profile makes public transport projects difficult to justify – especially when market shares heavily favour the automobile – using discounted cash flow evaluations, which concentrate on the potential and summative impact on society's welfare. Whilst welfare changes are important, this study provides a wider view of the potential benefits of a transport investment through the presentation of a methodology that combines the wider economy impacts of an investment with the impact of the investment on the economic performance of the spatial area in which the investment is located.

This paper presents an extended evaluation analysis using Economic Impact Analysis (EIA) in addition to the welfare based Cost Benefit analysis (CBA) to provide a more holistic view of the benefits of public transport investment. The extended analysis is performed using TREDIS (Transportation Economic Development Impact System). In a practical example, a proposed bus rapid transit (BRT) project in Sydney Australia is used to identify the role of the economic impacts and to show how economic impact analysis contributes to a better understanding of the opportunities offered by public transport investment.

The paper is structured as follows. The next three sections are generic to transport evaluation: Section 2 sets the stage by identifying analysis requirements to support transport investment decisions and the factors to be considered; Section 3 discusses methodological differences between CBA and EIA, with Section 4 discussing the uses of these methods to inform transport decisions, and introduces the TREDIS framework for applying them. The remainder of the paper focuses on the specific case of BRT in Sydney with Section 5 describing the Sydney case and Section 6 presenting the findings on CBA and EIA analysis. The final section discusses the implications of those findings and conclusions for future studies.

2. Requirements for Decision Support

The process of infrastructure investment planning, funding and implementation commonly involves a series of distinct decision stages, which tend to apply across nations. They typically follow a sequence as follows (Weisbrod and Lorenz, 2013).

- Vision and Long Range Plans. The initial stage is the development of long term strategic policies and plans for a state or region. They typically reflect a dialogue among elected officials and citizens regarding strategic goals and priorities for spatial growth and improvement in terms of economic growth, transport infrastructure and quality of life factors. In the context of Sydney, examples include the Long Term Transport Master Plan for NSW (Transport for NSW, 2012a) and the Plan for Growing Sydney (NSW Planning and Environment, 2014).
- Prioritization of Individual Projects. The second stage is the selection of a list of projects to be considered for near term implementation or the identification of corridors for priority: the former is US practice and the latter the NSW, Australia practice. In the US, the selected projects are typically appraised by rating them in terms of the economic efficiency of investment (using cost-benefit analysis) and achievement of desired strategic planning goals (using multiple criteria assessment). The latter technique may also consider distributional consequences and cumulative effects that reinforce policy goals and support the value of pre-existing investments. In NSW, Australia, this process took place at the spatial level of the corridor; the approach was broadly the same with a screening CBA undertaken on projects designed to improve corridor issues.
- Alternatives Analysis. The third stage is an analysis of alternative designs for projects that were provisionally selected in the prior stage. It encompasses corridor studies, alternatives analysis and environmental impact assessment. The alternatives typically span choices for mode and technology solutions, location and engineering design features. This stage enables more detailed project cost and impact estimates to be generated, and its appraisal supports agency decisions regarding design specification and feasibility determination. The factors considered at this stage include engineering, regulatory, economic impact and financial

feasibility. The Northern Beaches BRT Pre-Feasibility Study in the Sydney area is an example of this type of alternatives analysis (Transport for NSW, 2012b).

- **Project Funding and Implementation.** The fourth stage is the determination of when, whether or how the project can be funded and constructed. It commonly encompasses a pass-fail screening test to confirm that the project passes both a “return on investment” test, and a financial cash flow test. This supports agency decisions regarding funding commitments and moving forward to implementation.

The critical point being made here is that transport decision making involves a series of steps involving a range of different criteria to be considered. These criteria become important later in Section 4 where we consider how different forms of economic analysis can address them.

3. Contrasting Analysis Methods

Economic analysis can take many different forms. The most widely used forms for transport appraisal are cost benefit analysis (CBA), economic impact analysis (EIA) and financial impact analysis (FIA). Each applies systematic economic analysis principals to the same core data on transportation system changes but views them from a different perspective. These differences span the three measurement dimensions of time, space and impact elements but are connected through their use in different domains over time. The convergence in use of, particularly CBA and EIA are addressed first before turning to a more specific consideration of the time, space and impact elements. FIA is not considered in this paper.

The conventional measurement of benefits in CBA has focussed on the economic value of user benefits, and later the value of reducing emissions (DfT, 2010; AASHTO, 2010.) The measurement of economic impacts in EIA, on the other hand, had started through the use of macroeconomic models that showed the broader consequences of expanding markets and reducing costs for industries, leading to impacts on business competitiveness and consequently regional economic investment and growth in terms of jobs, income and gross domestic product (GDP) (Weisbrod, 2008).

An interaction of EIA and CBA occurred in the USA when economic impact models were used to evaluate productivity impacts of expanding market access, and net income growth was added to benefit/cost ratios. This included early studies that focused on showing benefits of expanding truck delivery areas and hence supply chains (Weisbrod and Beckwith, 1992). Later EIA studies were used by some USA states to compare total economic growth impacts to project cost (Kaliski et al., 1999). EIA was subsequently applied to show the wider economic benefits of extending rail transit lines to expand labour market access for central cities (HDR, 2010). All of these economic impact studies utilized regional macroeconomic models.

Subsequently, market access benefits were recognised in a series of research studies of urban agglomeration and productivity, and the effects of transportation access on effective density of employment (DfT, 2005, Graham, 2006). The broader research is reviewed in a recent Australian study (SGS, 2011). This line of research led to revision of CBA guidance in the UK (and later Australia) to include “wider economic benefits” that affected economic productivity. These revisions yield calculations of productivity change that represent direct changes in GDP, but are more limited than the broader GDP effects predicted by a macroeconomic impact model. The

reason is that macroeconomic impact models go beyond direct productivity effects to estimate the broader GDP consequences resulting from spatial and temporal shifts in business investment, trade patterns and business locations, as well as price impacts of shifting the supply and demand for labour, capital and shipped products.

Whilst the expansion of CBA to include wider economic benefits is fully appropriate, it has also had an unintended consequence which has been to confuse the appraisal practice. The confusion concerns the difference between the narrow set of GDP impacts covered within cost benefit analysis, and the potentially broader macroeconomic impact consequences also affecting GDP outcomes in an economic impact study. The problem is particularly acute as cost-benefit guidance in the UK uses the terms “wider economic benefit,” “wider economic impact,” and now also “wider impact” to denote direct effects on GDP that are significantly narrower than the GDP impacts covered by an economic impact model (DfT, 2005; DfT, 2014).

It is a misconception that any impact outside of formal CBA must be a qualitative factor, as otherwise it would be included in CBA. The reason why some elements of GDP or value added impact are reflected in EIA but not in CBA is that CBA is fundamentally an economic efficiency measurement, whilst EIA also considers both distributional impacts and broader structural changes in the economy that are beyond the direct efficiency measurements of CBA.

EIA provides a way for additional strategic impacts to be measured in quantifiable terms. For example, the achievement of desired goals for economic growth can be measured in terms such as changes in the breadth of jobs available and their average wage rates, drawn from an EIA. Distributional impacts can likewise be measured in terms such as the impact on variation in income among regions. Cumulative effects among combinations of multiple projects can also be measured in terms of their combined economic impact on GDP or value added. So EIA can be useful to generate ways to measure these effects. And whilst CBA can in theory also recognize distributional outcomes by assigning a shadow price or welfare value, caution is required as this is both hard to accomplish and could also undermine the efficiency interpretation of CBA results.

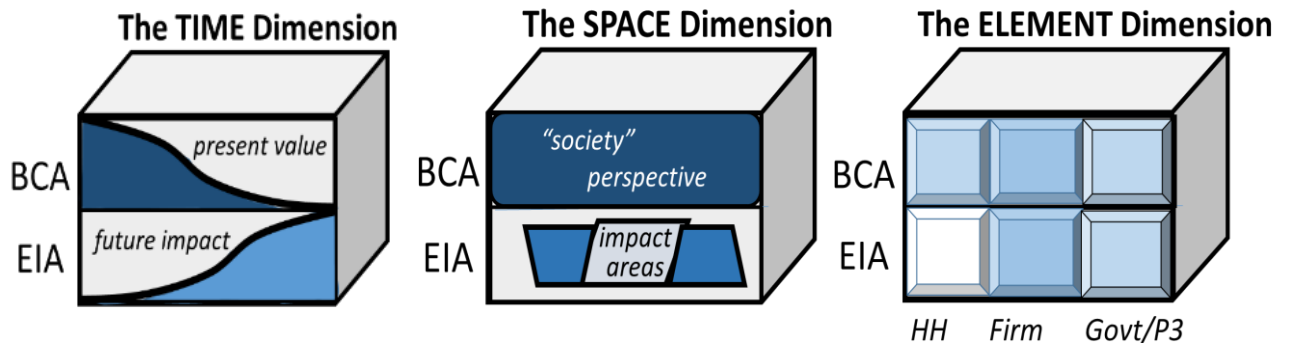
This paper seeks to provide clarity in these issues by showing how the CBA and EIA, as two forms of economic analysis, cover different issues and can play complementary roles supporting transport planning and appraisal. To do this, the fundamental distinctions between CBA and EIA in their coverage of the dimensions of time, space and impact elements are considered next.

3.1 The Time Dimension. (See Figure 1, first box.)

- CBA compares the discounted net present value of social benefit streams and cost streams, and provides a measure of the efficiency of investments in terms of their relative payback value. For transport projects that may take many years of planning and development, the discounting process is important as it adjusts for the fact that costs tend to be incurred largely in early years before the project is completed, whilst benefits tend to occur in later years well after the project is completed.
- EIA, in contrast, portrays the expected change in the economy of a designated area at future points in time, without discounting. For transport projects, this can be used to identify both the short-term consequences of projects (often associated with construction activities), and the long-term consequences (often associated with cumulative impacts of transport system performance changes). This includes cumulative economic growth generated in future

years because of direct changes in productivity and the broader consequences of changing regional competitiveness.

Figure 1. Treatment of time, space and elements of the economy, by form of economic analysis



3.2 The Spatial Dimension. (See Figure 1, second box.)

- CBA may be undertaken for a specific viewpoint, but it typically has no explicitly stated spatial boundary for benefit measurement, particularly for transport analysis. Thus it may appear that benefits are being counted for all users as well as external beneficiaries. However, in practice, there are implicit boundaries, for coverage is typically limited by the network coverage of transport models. Most commonly, the benefits of a transport improvement appear to increase as the network coverage is expanded.
- EIA, in contrast, always has a spatial boundary since it reflects impact on the macro economy of specified areas. EIA may portray the pattern of impact for a single area, for multiple areas, or for different breadths of coverage (e.g., local, state and national perspectives). The study area is important as economic impacts reflect changes in the spatial location and flow of imports, exports, capital investment and jobs. Some areas may gain economic activity while others may lose. These spatial relocation effects can make the economic growth impacts of a transport improvement appear largest for the area where the transport improvement is located, and appear smaller when a broader study region is defined – the opposite of CBA results.

3.3 The Impact Element Dimension. (See Figure 1, third box, and also Figure 2 below.)

- CBA in theory covers all social welfare benefits and costs, including both users and non-users of transport facilities. In practice, CBA is often limited to impacts that can be measured in quantitative terms and translated into a monetary valuation with other impacts only receiving a qualitative assessment. The current state of practice involves three further assumptions: (a) that there is an independent valuation for each type of impact, (b) that the relative valuations reflect trade-offs among the different types of benefits and costs, and (c) these effects are additive for calculating total impacts over time (UK Dept. for Transport, 2013; US Transportation Research Board, 2010).
- EIA, in contrast, covers macroeconomic impacts on the flow of money in the economy of a designated study area. This makes it narrower than CBA in some ways and broader in other ways. It is narrower because it is limited to impacts on money flows (costs, expenditures and/or revenues) in the economy, so non-money welfare gains are ignored. But it is broader because it captures distributional changes occurring over time,

across space and among sectors of the economy. This can include changes in labour, capital, workforce and/or population movements –which can lead to further shifts in productivity, inward investment, export growth and import substitution. The current practise involves use of regional macroeconomic models that calculate changes in economic flows as a cumulative function of factors affecting regional competitiveness (rather than trade-offs among individual factors, as assumed in CBA). (For examples see Weisbrod, 2008 and Duncan et al, 2013).

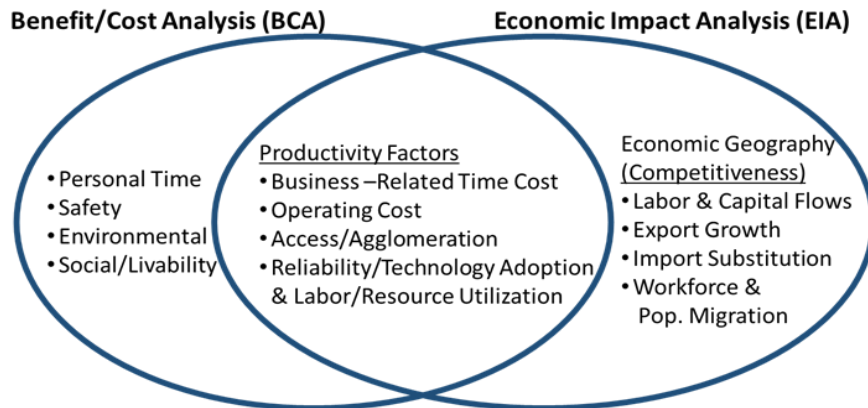


Figure 2. Difference in coverage of economic benefits by CBA and economic impacts by EIA

4. Matching Analysis Methods to the Context of Decisions

An old saying is that if you are a hammer, everything looks like a nail. A more recent joke among physicists is that if you have an accelerator then everything starts to look like a particle. A parallel can apply to those proponents of the classic form of benefit-cost analysis, who view every decision in terms of CBA. The point of this paper is that there are multiple forms of economic analysis that can help inform transportation planning decisions. After all, CBA compares a single total benefit metric against a single total cost metric. Yet one of the most useful types of information that can be extracted from EIA is insight into the mix or distribution of impacts over time, over space and over various impact elements (types of effects and types of affected parties). These methods can be matched to the planning decision stages introduced in Section 2 of this paper as follows:

- The visioning and long-range planning stage typically involves consideration of trade-offs among alternative future scenarios for regional growth and development, which represent different combinations of transport, economic and environmental outcomes. The determination of what constitutes the preferred future scenarios is informed by insights regarding investment, employment and income impacts and their spatial distribution as they evolve over time – a form of analysis that can be informed by EIA. Those same insights cannot be extracted from an analysis which puts all efficiency impacts into a single benefit metric presented as a present value as with CBA.
- The project prioritization stage requires a rating of each project on the same scale, regardless of differences in project location or time scale. CBA is most applicable here, as it can provide a net benefit metric that encompasses all classes of travel and trip purpose, and applies across all project locations and time scales. However, the economic efficiency measure provided by CBA is sometimes seen as just one part of a broader set of appraisal criteria that can also include the impacts of investments in achieving strategic vision goals. These goals

can include economic growth impacts and distributional equity impacts, as well as other social impact factors (such as environmental impacts and cumulative effects) and, for this reason, some form of multi-criteria rating system is commonly utilized for the prioritization process (particularly in the US) and that process often also include EIA outcomes (Weisbrod and Simmonds, 2011).

- The alternatives analysis stage turns the focus of analysis to the issue of how different alternatives for siting and design of a single project will affect its impact area -- now or in the future. That decision can benefit from economic and environmental analyses that are clearly tied to a specific study area, and hence EIA can be particularly useful as a way to distinguish the impacts of project alternatives, although CBA is also important to establish the efficiency of investment for the preferred alternative. The BRT case in the next section of this paper focuses on implications for alternatives analysis.
- The stage of project funding and implementation requires consideration of financing options for project development as well as ongoing operation and maintenance. At this stage, financial impact analysis is required in addition to CBA to ensure that a project having a positive welfare return to society also has sufficient financing and cash flow to be feasible for implementation and continued operation.

The next stage is to see how the principles outlined in Sections 2 through to Section 4 illuminate the understanding in a practical case. The example here is drawn from the Pre-Feasibility Study in the Sydney area and is discussed next before turning to the practicalities of how the appraisal was undertaken.

5. The Bus Rapid Transit (BRT) Case Study and its Evaluation Process

5.1 The Bus Rapid Transit Case.

Having use of CBA and EIA in abstract terms, the question now arises as to how these issues relate to that specific analysis of bus rapid transit (BRT). The application to a bus mode, albeit a high quality bus mode, is novel because nearly all of the literature on productivity and wider economic impacts addresses either highways or rail transit. The applicability and usefulness of these economic evaluation methods in the setting of BRT is unproven. Accordingly, this paper seeks to examine the value of EIA in complementing a CBA evaluation of different BRT options for a corridor in the Sydney Metropolitan area of NSW, Australia.

The selected case is the Northern Beaches BRT project. The project was designed to provide a public transport service that more directly connects major residential centres of the Northern Beaches area to urban employment centres and specifically the Sydney CBD. Movement between those areas is currently limited to a series of bus lines along several highly congested roads. BRT offers a form of mass transit that can combine the efficiencies and quality of metros with the flexibility and relative low cost of buses, whilst offering significant environmental benefits. The options developed for consideration in this case included different mixes of service frequency, dedicated roadway, quality of stations and vehicles and real time information. They ranged from full BRT service in the median of a road, along kerbside lanes, or via a dedicated bus lane with a bus tunnel, and also included an option for lesser improvements including transit lanes, road intersection upgrades, and bus priority at traffic signals.

Options considered for the Northern Beaches pre-feasibility study:

- 1: Bus Priority Improvement -- Upgrade existing kerbside bus lanes to 24 hour
- 2: Median BRT -- Segregated median BRT lanes and local buses on the kerbside
- 3: Kerbside BRT -- Segregated kerbside BRT lanes and passing bays at all bus stops
- 4: BRT with Bus Tunnel -- Kerbside BRT on Pittwater Road and bus tunnel under Military Road
- 5: North Side interchange BRT -- Segregated kerbside BRT lanes with rail interchange at N. Sydney

The Northern Beaches BRT plan had initially gone through a process of pre-feasibility study that included benefit-cost analysis (Transport for NSW, 2012b), and a subsequent economic impact study that considered wider economy impacts (Institute of Transport and Logistics Studies (University of Sydney) and Economic Development Research Group, 2012) and further public consultation. This paper presents and further interprets results of the latter study.

The initial development of the BRT plan options and the public discussion about its importance was driven by a number of practical and strategic considerations. From a practical viewpoint, there was a strong consensus that growth of communities along the north coast was leading to growing traffic congestion, which was becoming an increasingly problem as travel times were increasing and becoming more variable (less predictable). Moreover, there was significant intra area travel accounting in total for eight times the number of commuter trips (Transport for NSW, 2012a, 154).

A further issue was the way in which the Northern corridor passed through North Sydney (with one of the options having a bus-rail interchange there). North Sydney is a key part of the 'Global Arc', a high income area "formed [and] reinforced by the high tech industries of Macquarie Park and Macquarie University (modelled on Stanford University's nexus with Silicon Valley) stretching to the airport via the CBD's of North Sydney and Sydney and 5 of Sydney's universities" (Meyer, 2006, 7). Strategic planning identifies an expansion of the Global Arc to support the projected growth of Sydney (NSW Planning and Environment, 2015).

Within the Northern Beaches corridor, further traffic and trips were anticipated from the building of a new health precinct at Brookvale/Dee Why, again as part of responding to planned growth in this area as the population of Greater Sydney expands.

Hence, from a strategic viewpoint, a series of public goals were calling for continuing economic growth of the Northern Beaches corridor, with its subregional centre status being recognised as part of the planned growth for the Greater Sydney Region. The plan for growth also included the building of a new hospital precinct, as well as a desire to improve the connectivity between subregions and the Global Arc to expand access to employment opportunities. In other words, whilst the practical viewpoint called for evaluating BRT options in terms of conventional user benefits (travel times and costs) in a cost-benefit analysis, the strategic viewpoint called for consideration of the long term consequences for regional economic development impacts through the consideration of wider economic impacts – including agglomeration benefits associated with increasing job/labour market access, as well as further implications for regional economic growth – via an economic impact analysis. Moreover, all three levels of government are aligned on the context and need for the corridor improvement to the Northern Beaches area as shown by the following quotes:

- From a national perspective, the “Project aligns with the Infrastructure Australia theme of ‘transforming our cities’ as well as contributing to Australia’s economy with the economic and productive capacity of Sydney enhanced by improving access between the labour market population growth areas and the job centres” (Transport for NSW, 2012b, Infrastructure Australia, 2008).
- From a state perspective, the project was identified in the NSW Transport Master Plan as a medium term priority, based on criteria that “the busiest, development-rich bus corridors within this network will be candidates for conversion to high capacity modes such as Bus Rapid Transit” (Transport for NSW, 2012a, 130-136).
- From a regional perspective, the Sydney growth plan identified Brookvale/Dee Why and the Northern Beaches Hospital Precinct as strategic development centres, and it called for action to “improve subregional connections, particularly from the Northern Beaches to Global Sydney and the Global Economic Corridor” (NSW Planning & Environment, 2015 update, 124-126).

5.2 Application of the TREDIS Framework.

Both the CBA and the EIA was conducted using TREDIS (the TRansportation Economic Development Impact System). TREDIS is an “analysis framework” that uses scenario-level input data to holistically estimate economic impacts, cost-benefit measures and financial impacts of implementing a “build” alternative versus a “no-build” or “do-minimum” alternative. It provides a consistent system for applying the different forms of economic analysis across space, time and elements of the economy as discussed earlier in Section 3. The process used for applying TREDIS is shown in Figure 3; the individual elements are summarised below.

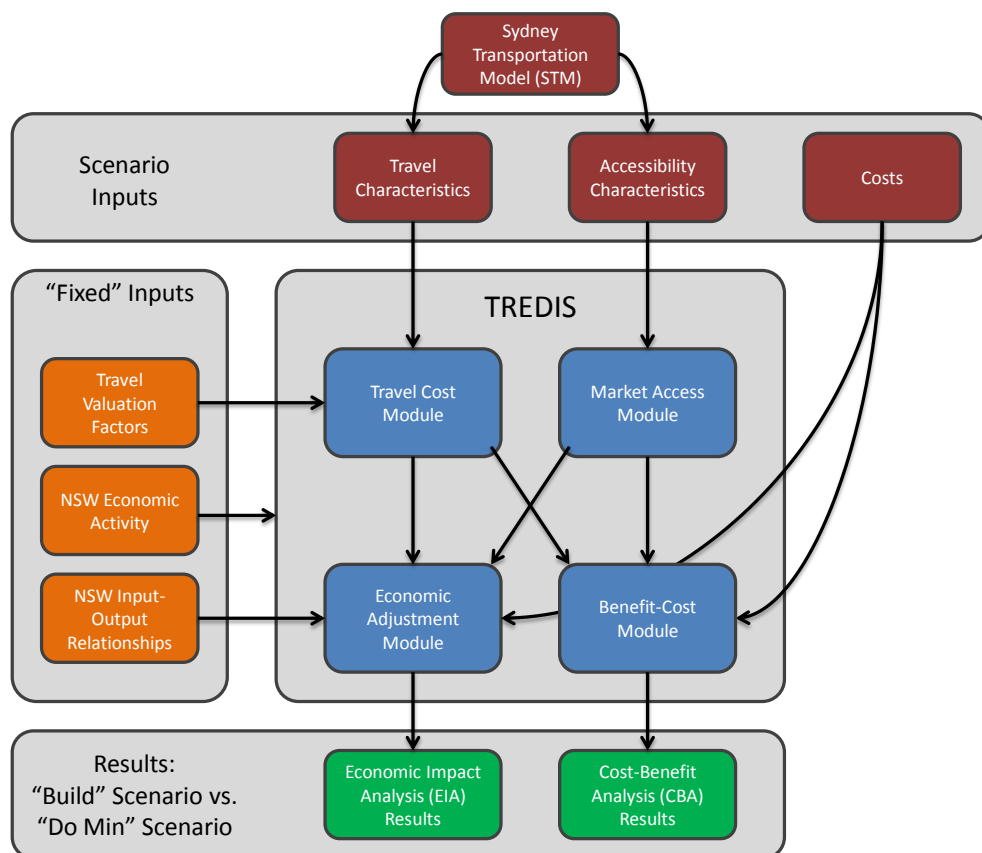


Figure 3 Analysis process flowchart

The “*Scenario Inputs*” shown in Figure 3 include the characteristics of the do-minimum option and five BRT options. There are three categories: travel characteristics, accessibility, and costs.

- Travel characteristics describe the quantity and quality of travel for a particular scenario in terms of trips, distance, travel time, tolls and fares, congestion levels, crowding levels, and reliability. These measures were estimated from two travel models developed by the Bureau of Transport Statistics (BTS) of Transport for NSW (TfNSW): Sydney’s Strategic Transport Model (STM) and the Freight Movement Model (FMM).
- Accessibility characteristics describe the additional effect of travel times and congestion on the “effective density” of activities within the regional economy, which can affect regional economic performance over time, independent of travel cost savings. Accessibility inputs were calculated using zonal employment data and inter-zonal travel times within region. Effective density improves when an investment scenario reduces inter-zonal travel times.
- Cost characteristics include predicted costs of construction, maintenance and operations over time, as provided by TfNSW. These costs are used in CBA, but the stimulative effect of on the economy is also estimated in EIA. The construction costs are temporary, though operations and maintenance costs support ongoing employment and income.

The “*Fixed*” inputs shown in Figure 3 are factors that remain constant for all scenarios and include factors for determining the costs of travel, including travel time, vehicle operating costs, accidents and emissions. These cost factors are based on State government guidance, as provided by TfNSW, and previous research undertaken at the Institute for Transport and Logistics Studies (ITLS) at the University of Sydney. In this category are economic data describing past and current activity including employment and GDP across industry sectors, as well as data describing inter-industry relationships – who buys what from whom in the Sydney metropolitan area economy.

The *TREDIS* modules shown in Figure 3 generate the cost-benefit, economic impact and financial impact results.

- The Travel Cost Module uses output from the STM and FMM demand models, along with the fixed factors, to estimate changes in modal vehicle and passenger volumes, travel times and operating costs over time, and their distribution among sectors of the economy.
- The Market Access Module estimates the agglomeration effects of transportation investment. It utilises measures of market access in terms of “effective density” (as measured by the STM model for alternative scenarios). It then applies coefficients representing statistical relationships between economic productivity, concentration of industries and the scale of markets for labour, material inputs and customer demand.
- The Economic Adjustment Module incorporates behavioural models to determine how results from the travel cost and market access modules lead to additional economic activity. It uses data on local economic patterns and inter-industry relationships, with a dynamic impact forecasting model that estimates changes over time in productivity, competitiveness and economic growth (in terms of jobs, GDP, income, etc.) It draws on economic model data produced for NSW by the Centre of Policy Studies at Monash University (now at the University of Victoria).
- The Benefit Cost Module assembles inputs and intermediate calculations for scenario cost, traveller savings (including external benefits of emissions and safety), and wider impacts.

These are discounted on a year-by-year basis to determine the net present value and benefit-cost ratio for each option.

In this case, there are several aspects of this analysis process that are particularly notable. First, the Market Access Module calculates only impacts that are additional to the direct impact on travellers that occur in the form of savings in travel time and the vehicle operating – which is covered by the Travel Cost Module. This means that the market access module counts the scale economies accruing to certain providers of goods and services because transport improvements enable them to effectively access broader (and more specialized) markets for workers, suppliers and/or customers, and/or to more spread fixed costs of facilities operation over a larger customer base. These are productivity improvements in non-transport activities that are enabled by transport improvements.

The TREDIS approach to estimating these impacts follows the work of Krugman (1991) who showed that, with imperfect competition, regions develop differentiated industry mixes that reflect “agglomeration economies.” The agglomeration is reflected in a disproportionately large concentration (or cluster) of some activities. It is typically enabled by access to larger markets, which in turn brings demand for greater product variety and enables firms to realise increasing returns to scale (i.e., lower cost). This effect can reflect not only production scale economies (spreading fixed cost over a wider base to reduce unit costs), but also economies associated with greater access to differentiated inputs (i.e., cost and quality benefits associated with greater ability to acquire specialised labour and materials). The effect is driven by inter-industry linkages (which create demand for specialised suppliers that varies by industry) – a concept further developed by Krugman and Venables (1995). The analysis conducted here utilized productivity impact factors in TREDIS that are generally consistent with the agglomeration elasticities developed by Hensher et al (2012a).

TREDIS has been used to measure market access impacts and model wider impacts on the productive economy of NSW resulting from TfNSW’s Rail Strategy and for the evaluation of the National Highway Upgrade Programme (Wang, 2015). This BRT case is different from the cases of highways, in which the scale and density of markets may be expanded for either freight deliveries (affecting incoming materials and outgoing shipments) or passenger travel (affecting worker/job access and retail industry markets). In the case of BRT service, the primary market access benefits are for passenger access between the Sydney CBD and outlying communities.

A second notable element of the analysis process is use of the Economic Adjustment Module to estimate intermediate impacts on travel cost and market access changes on supply, demand, prices, productivity and competitiveness for various industries in the region. The module utilizes a regional economic model that is dynamic and forecasts changes over time in local production, exports to outside areas and inward investment – all of which ultimately leads to projected impacts on regional employment, income and GDP. This is similar to a Computable General Equilibrium (CGE) model in that it incorporates supply/demand and price changes over time. However, it differs from a CGE model by being tailored to regional-scale transport impact studies through recognising that (a) regional labour supply is fixed in the short run but elastic in the long term, and (b) regional market access and reliability shifts can enable productivity growth for technology-based products and services and related export industries, beyond just the savings in generalised costs for travellers.

6. Analysis Results

6.1 Cost-Benefit Analysis.

The pre-feasibility study generated initial measures of project costs and travel benefits that were input to TREDIS for the EIA. Study results regarding the benefit cost ratio (BCR) are shown in Table 1, and key findings are summarised below.

Table 1. CBA Results: Alternative Views

	(A) Traditional BCR <i>Pre-feasibility Study</i>	(B) Traditional BCR <i>ITLS/EDRG analysis</i>	(C) BCR mark-up for Wider Econ Benefits
1. Priority Improvement	0.67	1.24	23%
2. Median BRT	0.71	0.71	23%
3. Kerbside BRT	0.62	0.62	23%
4. Bus Tunnel	0.38	0.66	16%
5. North Side Interchange	0.67	0.85	18%

- Column A shows the final CBA results issued by TfNSW in 2012 (TfNSW, 2012b), following a refinement of a broad list of alternatives and the analysis of them. These numbers cover only traditional benefit measures (time, cost, safety and emissions), and assume a 7% real discount rate in accordance with Australian standards.
- Column B shows the CBA results from the 2012 study for the benefit cost ratio (BCR) (Institute of Transport and Logistics Studies (University of Sydney) and Economic Development Research Group, 2012). The BCR results did not change for options 2 and 3 (median and kerbside BRT), which are the two options providing dedicated BRT service throughout the entire length of the corridor. However, the benefits and hence BCR results were increased over the pre-feasibility study as a result of using different data on catchment area and thus different outcomes from the demand modelling.
- Column C shows the BCR mark-up that would result from adding wider economic benefits, which in this case is primarily the effect of increased market access (agglomeration) (Institute of Transport and Logistics Studies (University of Sydney) and Economic Development Research Group, 2012). The mark-up rate is similar among the first three options shown but drops for the latter two, reflecting issues identified above: (a) less direct access for North Sydney residents under *Option 4* as a tunnel would limit local access options and thus BRT use to and from North Sydney and (b) less direct CBD access for residents located further north (due to bus-rail transfers required at the North side interchange) under *Option 5*.

The analysis in Table 1 was carried out using the 7% rate required by the NSW Treasury. Many other jurisdictions use a rate closer to the real cost of capital (3.5% in the UK, 4% elsewhere). Using a lower discount rate would increase all the NPVs. Further analysis shows that all the options would approach a BCR of 1.0 with a lower discount rate of 4%, based just on traditional BCA calculations and a BCR in excess of 1.0 if wider economic benefits are added. It can be seen from Table 1 that adding in wider economic benefits will not change the rankings among the options. However, the methodology has the potential to affect project rankings in other situations, because it is based on specific accessibility measures that can diverge from travel cost savings.

This sets the stage for further consideration of wider economic benefits and interest in EIA results to see if strategic goals are being met.

6.2 Economic Impacts across Time.

Given that the CBA analysis still showed relatively modest net benefits (beyond costs), the potential contribution from an economic impact analysis for policy-makers is particularly important, as EIA provides the means of examining whether or not the BRT options offer other desirable impacts in terms of regional economic development and growth goals which are synergetic with the strategic goals discussed above. These EIA results are described next.

Whilst *short-term construction impacts* are an outcome of spending and not a net social benefit, they do generate temporary jobs. There were important differences among the options in terms of both the magnitude of construction-related job generation and its timing. Initial study results showed that the bus tunnel (*option 4*) would generate the most temporary jobs/year, but it would take the longest time -- till 2023 – before it would be completed. The priority investment (*option 1*) would generate the least jobs/year, but it would be completed the soonest – by 2018. The other options would be completed shortly thereafter – by 2020. In contrast, comparing *options 1-3*, the speed with which *option 1* could be completed provides the major difference in efficiency measurement (with CBA) since the travel benefits ‘kick in’ earlier and are therefore not so heavily discounted. Thus *option 1* benefits in CBA but loses out in EIA for the short-term construction impacts. Similarly, it is the longer construction times associated with *options 4 and 5* which work against these options in the efficiency measurement but work in their favour for the generation of temporary jobs during construction.

The *long-term economic impacts of BRT completion* are of a greater interest for this study because they represent the cumulative effect on the regional economy resulting from enhancing travel conditions (a cost reduction effect) and expanding labour/job market access (an agglomeration effect. Table 2 shows the difference between BRT implementation scenarios as compared to a base case in which no BRT is implemented. The results are shown in term of the difference in total jobs, worker income (compensation) and value added generated in the Sydney metropolitan area as of the year 2026. These numbers reflect the cumulative effect of an increase in annual economic growth each year over a 20 year period.

Table 2: Long-term economic impacts by investment option, as of 2036

	Jobs	Worker Compensation	Value Added (GRP)
1. Priority Improvement	3,937	\$ 225 million	\$ 335 million
2. Median BRT	3,813	\$ 218 million	\$ 324 million
3. Kerbside BRT	3,829	\$ 219 million	\$ 326 million
4. Bus Tunnel	5,488	\$ 316 million	\$ 471 million
5. North Side Interchange	4,263	\$ 241 million	\$ 359 million

As with construction impacts, long-term impacts vary year to year. Figure 4 shows the additional impact of BRT scenarios on growth of total worker compensation over time. The rate of economic growth peaks around the 2016 – 2020 period for all options except the Bus Tunnel (*option 4*), which peaks in 2022 because of its longer construction period. The rate of economic growth then slows in subsequent years. The steep growth in early years reflects the impact of reducing congestion and expanding labour market access within the region. This effect leads to cumulatively greater economic growth over time (compared to the base case), although the rate

of growth erodes in later years. The reason for this outcome is that, whilst BRT service (with reserved bus lanes and priority at intersections) does enable faster travel for public transport riders, there is a gradual erosion of travel speeds for cars and trucks travelling on the same corridor which becomes particularly notable in later years.

All options, other than *option 5*, include bringing the BRT into the CBD over the harbour bridge on a 24 hour bus lane. *Option 5* shows higher long term job impacts than *options 1, 2 and 3* as a result of interchanging to rail for travel from North Sydney to the Sydney CBD, thus avoiding eventual congestion growth on the bridge.

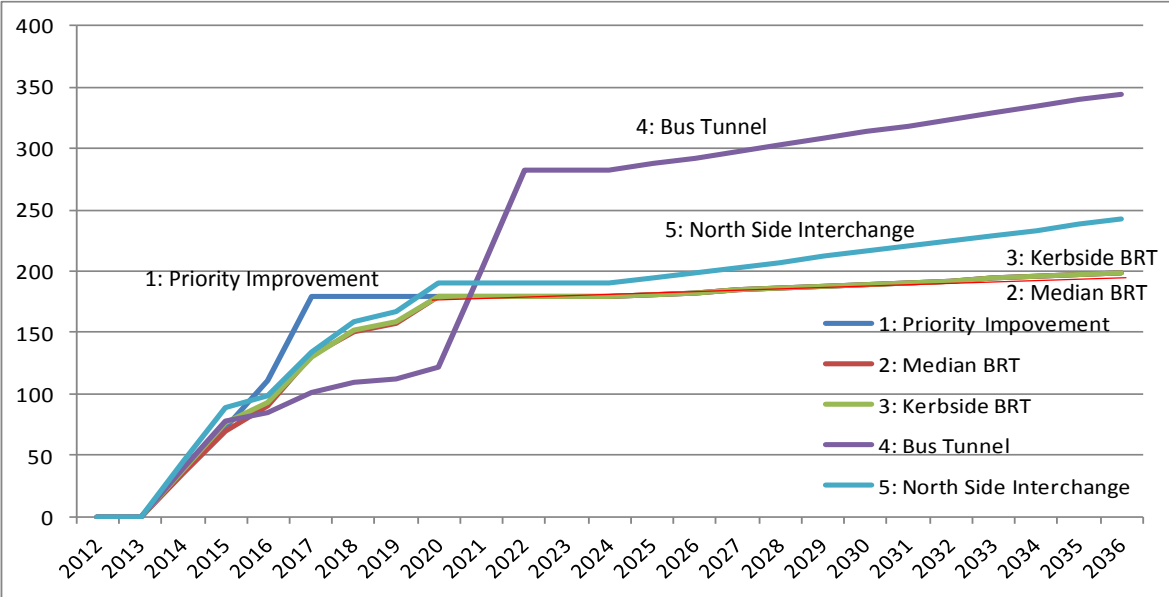


Figure 4: Phase-in of long-term impact on worker compensation, 2012 to 2036

6.3 Spatial Pattern of Economic Impacts.

EIA may also be used to examine how the economic impacts are distributed spatially. This can be done via multi-regional economic impact models that trace how *direct* productivity benefits and economic growth impacts in one area lead to additional demand for parts, materials and services suppliers provided by suppliers (*indirect* economic effects) in other areas. There can also be broader economic impacts in other areas due to changes in worker income and its re-spending (*induced* economic effects) and other spatial shifts in economic flows. TREDIS enables this type of analysis, which builds on information regarding both economic flows and commuting flows among areas.

For this BRT case, though, the analysis was simpler – the direct cost and access impacts were identified by transport zone and the broader economic consequences were modelled for the entire Sydney metropolitan area. The analysis showed that the direct impacts were concentrated in areas of improved worker/job access to the Sydney CBD and broader regional economy – primarily the North Beaches communities and adjacent north eastern suburbs, North Sydney and Sydney Central Business District, all part of the global arc. Figure 5 highlights the area of direct impact (shaded) within the broader economic region in which total impacts would be expected to occur.

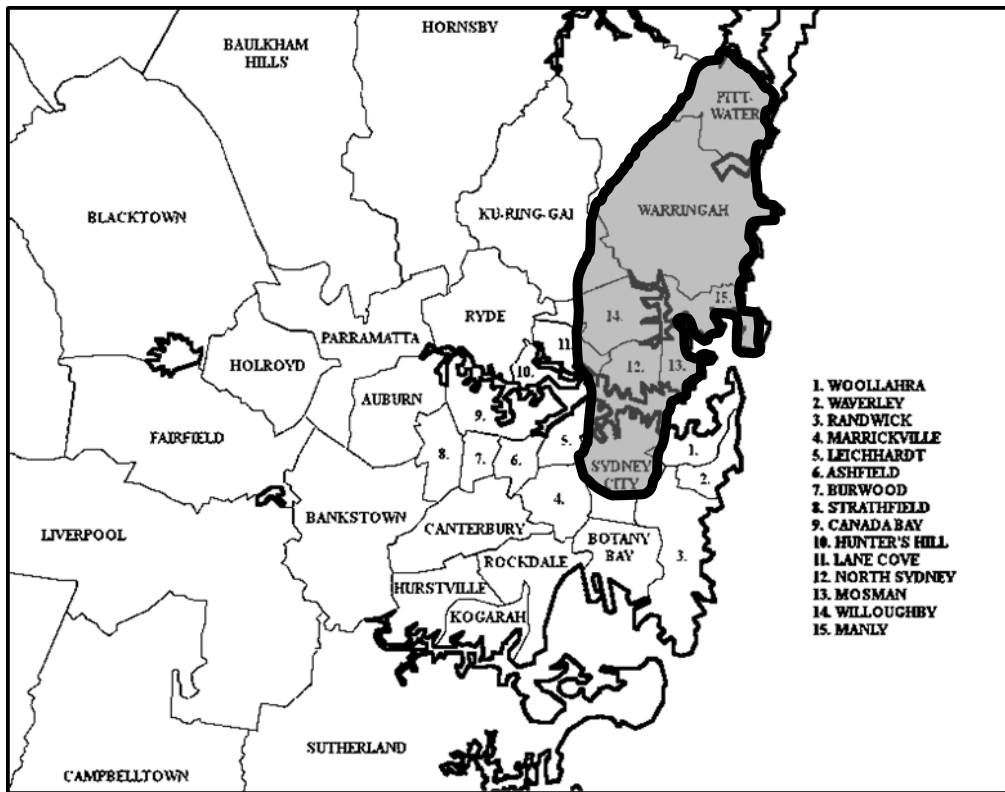


Figure 5. Area of direct impact within the broader Sydney metropolitan area
 (base map shows Sydney Councils, Licensed under CC BY-SA 3.0 via Wikipedia)

6.4 Economic Impacts across Sectors of the Economy.

Economic impacts are disaggregated by major industry group in Figure 6. This result shows that the industries gaining from BRT are disproportionately professional and business service-based industries, which are the industries that are also most dependent on access to skilled labour and benefit from improved passenger access. Retail sales are affected in a significant manner, consistent with supporting the growth in skilled labour activity.

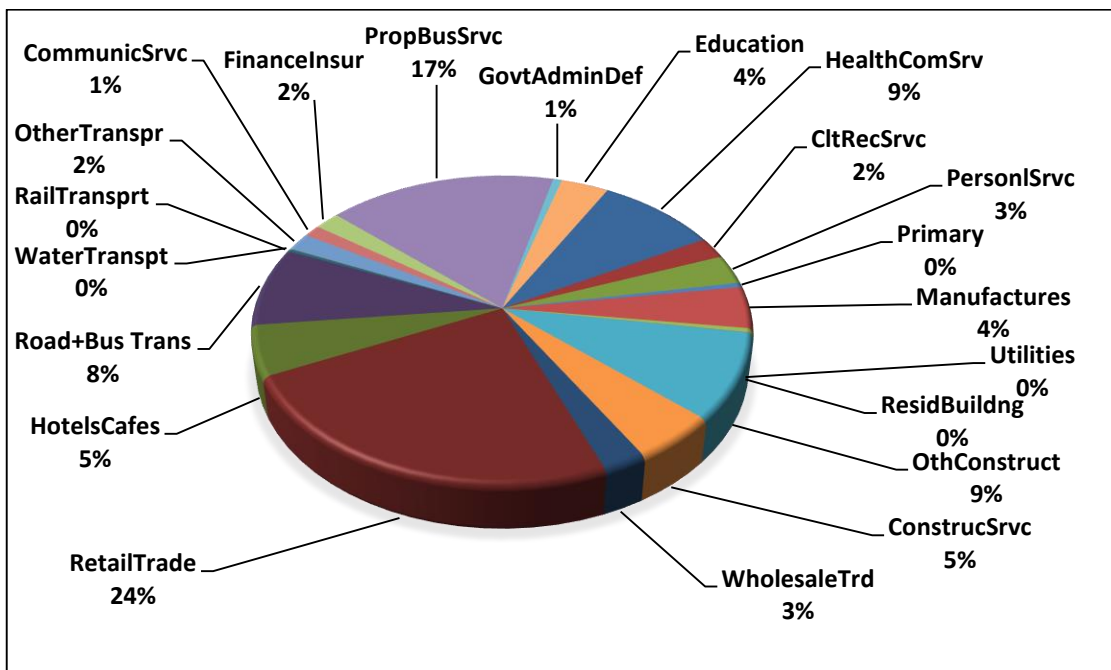


Figure 6. Area of direct impact within the broader Sydney metropolitan area

Figure 6 shows how the time and cost savings associated with the Kerbside BRT option affect different industries than the market access impact of that same option. To make this differentiation, the regional economic impact model was run twice: first considering only the travel time, cost and reliability effects as inputs, and second considering only the market access (agglomeration) effect as input. Each industry’s share of the predicted job impact was then compared to that industry’s share of current jobs in the region. There are three notable results:

- The *cost savings effect* was most concentrated on manufacturing and retail trades – that had shares of the job growth impact that were equal or greater than their shares of existing jobs.
- The *market access (agglomeration) effect*, in contrast, was greatest for communications, finance/insurance and business services –which accounted for larger shares of the job growth than their shares of the regional economy. These industries are disproportionately concentrated in the CBD, which gains from enhanced market access.
- Also gaining more from the market access gain than from the cost savings was wholesaling, education and health services. These industries are not concentrated in the CBD, but gain from scale economies associated with improved access to the regional market.

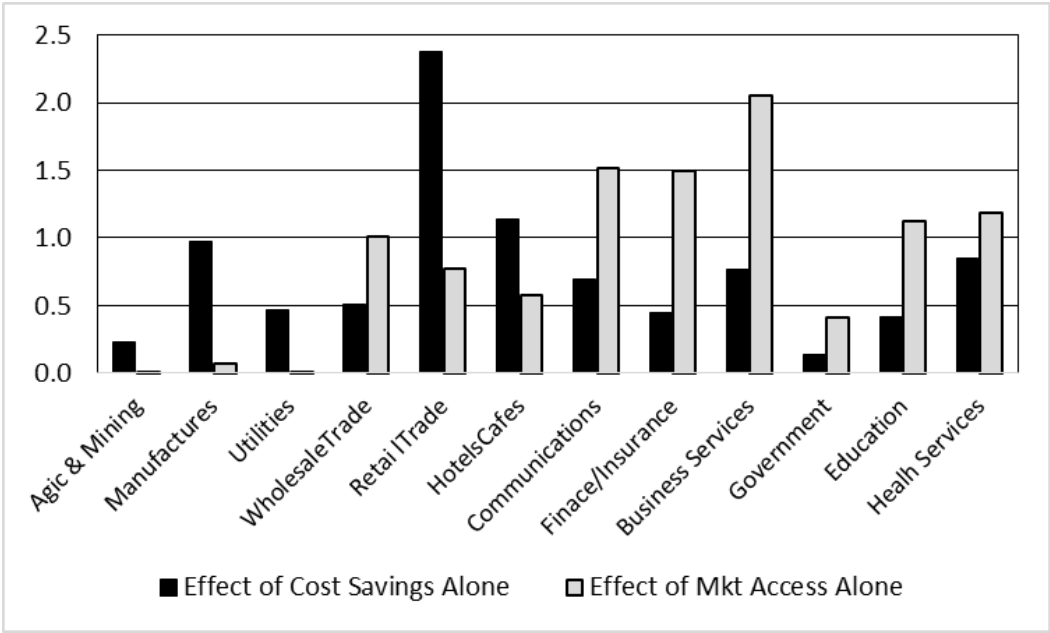


Figure 6. Predicted industry shares of job growth to 2036, relative to industry shares of current jobs in the region

It should be noted that all of the options considered in this case were generally along the same corridor, so they all had similar profiles of impact among sectors of the economy. That would not be the case if the options differed in their corridor alignments and hence varied in the affected spatial areas or affected highway and transit network links. For instance, consider the case where two options generated the same total savings in user cost, but one reduced congestion at a pinch point affecting a greater share of truck flows. In that case, the economic impact may be more concentrated on manufacturing and distribution activities that are most sensitive to travel time variability and just-in-time production and delivery processes.

In this way, EIA can be used to show differences among transport projects and options in terms of how they vary in their long run economic development consequences by industry. That kind of further insight, whilst not applicable for the Northern Beaches BRT options, can allow policy makers to better assess whether certain options better address wider strategic goals for economic development.

7. Discussion

7.1 Wider Perspectives.

Undertaking the twin analyses of CBA and EIA provides a wider context in which to discuss and communicate the outcomes of investment. Typically, many jurisdictions rely on the CBA results which are framed in terms of utility or social welfare. While welfare is important – it captures critical societal benefits such as reduced emissions and safety – it does not tell the “whole story”.

EIA provides a view of how the economy changes over time and provides another aspect to understanding whether or how the strategic goals of the jurisdiction are being met. EIA contextualises the project in terms of economic growth. When certain economic efficiency criteria are met (such as meeting the 1.0 benefit/cost ratio threshold), short and long-term economic growth can provide effective additional performance measures in project prioritisation. Because of the differences in methodology, EIA frequently brings new information to project selection – in many cases suggesting alternative project rankings. Strategic priorities are often determined by a need to resolve multiple objectives and considering social welfare and economic growth evaluations can identify which objectives are being met by which aspects of investment.

Moreover, beyond short term impacts, sustained economic growth is a legitimate concern of local, state, and federal governments. A key element of economic impact analysis is its ability to distinguish between spending-related impacts versus other productivity-enhancing impacts. Moreover, the different perspective of economic impact analysis provides new opportunities to communicate project impacts. Through its basis in social welfare, CBA delivers results along key social dimensions such as time savings, reduced emissions, and improved safety. These benefits, along with economic efficiency, can be effectively communicated through the exercise of CBA. In contrast, EIA impacts provide a completely different set of results to communicate. In particular, jobs and income are measures that resonate widely across a range of stakeholders, particularly politicians who are frequently identifying the job changes as a result of undertaking investment. Digging deeper into economic impacts, it is also possible to direct results to specific stakeholder groups: for example, public transport’s decongestion effect is beneficial to trucks, and the methodology presented here quantifies impacts to that to the truck sector, both in terms of travel cost savings and follow-on economic growth. Similarly, manufacturers and other industry groups can see how projects benefit them specifically.

7.2 Critical elements of investment

The TREDIS methodology has been used elsewhere to estimate the impacts of a broad variety of public transport or roadway investments. This experience identifies several key factors drive the overall magnitude of CBA and EIA results.

Ridership is perhaps the most important factor driving benefits and impacts of public transport investment. This is because it forms the basis of traveller cost savings, which is the starting point for both CBA and EIA. For projects affecting levels of service – for example, increasing speeds

or reducing dwell times, larger pools of travellers form a larger basis for applying the incremental traveller impact.

A related key factor is the ability to divert riders from cars, particularly during peak periods. Because commute periods are the most congested, attracting commuters to public transport can generate substantial congestion relief, thus generating time and vehicle cost savings for a much wider pool of cars and trucks. Moreover, reduced congestion can improve travel time reliability, which generates benefits from more efficient scheduling.

In all cases, the mix of trip purposes is important in determining benefits and impacts. For benefit-cost analysis, this is important because business travellers and trucks have higher value of time savings than personal travellers and commuters. More pointedly, because benefits to personal travellers generate no follow-on economic activity, EIA impacts depend on investments that benefit commuters, business travellers, and trucks. In terms of market access, public transport projects can generate benefits several ways. Most directly, as evidenced by this study, public transport can expand labour market accessibility, thereby generating productivity impacts which are incorporated into both CBA and EIA.

8. Conclusion

This paper has detailed the methods and data that are needed to investigate the wider economy economic impacts of transport infrastructure investment. The methodology and case study shows that wider benefits, included in both CBA and EIA, have the capacity to increase the benefits of a proposed project by including the longer term changes to market access.

In addition, the paper has used the methods that have been built into TREDIS over the last twenty years to assess the effects of project/policy on the economy in which it is located, known as EIA and measured by the change in Jobs, Business Output (sales), Value Added (GRP), and Compensation (wages and benefits). Changes in these measures are estimated across detailed industry group, providing the ability to determine not only how an investment affects different industries, but also but whether the jobs created are high or low wage. In turn this allows an assessment of the degree to which investment meets the multidimensional strategic goals. In the case study of this paper, the EIA showed job impacts into the longer term were synergetic with stated strategic goals.

Importantly, the case study of the BRT options for the Northern Beaches shows again the capability to reveal the economic impacts of transport investments within the well-established framework of TREDIS, and the types of data that are required in the Australian context to be able to advance the state of practice in evaluation of major projects. Such a demonstration is relevant to the ongoing commitment of promoting investment in transport infrastructure, especially public transport infrastructure, to funding agencies such as state-based Treasury and Infrastructure Australia.

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