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Application of the Input-Output Model to the Analysis of the Economic Impacts of Transport Infrastructure Investment in Australia

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Abstract

As a result of the deterioration of economic conditions associated with the Global Financial Crisis and its immediate aftermath, public investment is firmly back on the policy agenda, especially as a means to revitalise Australia's increasingly inadequate land transport infrastructure. There has been much controversy, however, over whether such investments are efficient, or whether public funds would have been better spent on other projects. It is clear that, for the investment of public funds to have the greatest positive effects, government agencies need improved ways of assessing the economic benefits arising from transport projects. This is clearly necessary so as to ascertain whether these projects sufficiently justify their cost.

Many cost-benefit studies of individual transport projects concentrate on narrow measures of economic benefits. Another type of research, focusing on economic productivity, defines benefits more broadly but is also limited by functional aggregation constraints. This research attempts to bridge these two perspectives through a modified input-output model that describes how project-specific analysis methodology can be unified with the overall macroeconomic effects of transport infrastructure spending. Scenario results show that a multi-sectoral input-output model can capture the sectoral difference nature of the economic impacts of different transport infrastructure and thus provide a reliable tool for more effective and strategic transport infrastructure planning.

Keywords: Transport Investment, Economic Impact, Input-Output Modelling

1. Introduction

The Australian land transport system, which primarily consists of roads, mass-transit systems and rail, is becoming increasingly congested. Furthermore, passenger and freight traffic is expected to grow substantially in the future, thereby necessitating continued investment in land transport systems (BTRE, 2006). As a result of the deterioration of economic conditions associated with the Global Financial Crisis and its immediate aftermath, public investment in capital works is firmly back on the policy agenda, especially as a means of revitalising Australia's increasingly inadequate land transport infrastructure. That said, determining which project proposals should be funded out of the public purse is an inevitably controversial process, more so since these decision are usually highly politicised. This paper seeks to deal with these thorny issues by proposing a more informed way to determine the overall economic value of infrastructure projects pertaining to the transport sector.

The development of effective transport systems, or the improvement of existing ones, typically requires investment of millions or even billions of dollars in public money, even in cases where a proportion of the project's costs are absorbed by the private sector. This is especially problematic in view of decreasing public revenues vis-à-vis the amount of expenditure necessary to realize salient public values, particularly as a result from a general retreat in the Western world from 'big government', a move which has widely resulted in the sale of public assets (Koppenjan et al., 2008). There has been much discussion, however, over whether such infrastructure investments, when considered on a project-by-project basis, are efficient, or whether public funds would have been better spent on other projects, such as health, energy or water infrastructure, all of which are also regarded as realising important public values (de Bruijn and Dicke, 2006). Competition, moreover, often exists between various transport-related projects for the same pool of public funds, something which further muddies the waters and can result in strategic misrepresentation on the part of those advocating individual projects (Bruzelius et al., 2002; Flyvbjerg et al., 2003). It is clear that, for the investment of public funds to have the greatest positive effects, government agencies need to employ the most suitable ways to assess the economic benefits arising from transport projects. This is clearly necessary so as to ascertain whether these projects sufficiently justify their cost, or whether the funds would be better spent elsewhere, including on competing transport-related projects.

Current research on this topic could well be regarded as incomplete, especially since it tends to focus on partial economic effects in a given locality or national economic effects of aggregate spending. cost-benefit analysis (CBA) used for individual projects, the most widely used method of appraising the economic efficiency of a project proposal, largely concentrates on counting the direct impacts of a project, which are principally time and cost savings (Keegan et al., 2007). Such traditional appraisals provide relatively little insight into the broader role that transport infrastructure plays in aggregate economic growth and productivity (Banister and Berechamn, 2001). On the other hand, macro-level studies on the relationships between overall capital investment and rates of change in productivity at the state and federal levels also exist (Aschauer, 1989; Graham, 2005 and 2006). Despite this, it may be argued that these studies tell us little about the actual mechanisms through which these benefits arise.

On account of these factors, and because there is a need for investment in more sustainable transport-related infrastructure (Kivits et al., forthcoming; Richardson, 1999), the need to explore and experiment with new methods that seek to assess economic impacts associated with transport projects in a more coherent analytical framework is becoming increasingly urgent. In Australia, cost-benefit analysis and environmental impact assessments are required for investments in infrastructure. However, the wider economic impacts have remained underexposed in ex-ante transport project appraisal. The major difficulty in including wider economic impacts in transport project appraisal is that they can take on many forms, some of which are particularly difficult to estimate with any precision (Keegan et al., 2007). In order to promote a move towards redressing this unsatisfactory state of affairs, this research attempts to bridge these two perspectives through a modified input-output model that describes how project-specific analysis methodology can be unified with the overall macroeconomic effects of transport infrastructure spending. The research as presented herein therefore has three broad and interrelated goals, which are as follows:

- To recap briefly the issues related to the assessment of economic impacts from transport infrastructure projects;
- To introduce a unified approach based on our review of existing literature; and
- To provide better guidance in regard to decision-making in the area of public funding for transport infrastructure projects.

This discussion first identifies the taxonomy of economic impacts and then critically assesses the current methods for both micro-level and aggregate-level analysis. A unified input-output approach is then used to illustrate how the analysis of impacts of specific transport projects can be measured more fully in a context consistent with overall productivity and other economic concepts.

2. A Taxonomy of Economic Impacts

The economic impacts of transport projects are so numerous and diverse that it is often difficult to make comprehensive benefit estimates. A good place to start is by organising the potential benefits into categories; that is, creating a taxonomy of benefits (Weisbrod, 1997). This research will therefore assign benefits to categories according to four dimensions arranged according to pairs, these being i) direct and ii) indirect effects, in addition to iii) short-run and iv) long-run effects. Table 1 below establishes a four-dimensional classification of transport project benefits. Short-run economic effects will occur during construction, directly and indirectly through demand effects, such as the demand of materials, labour, technical expertise and energy. Besides these effects, there will be direct and indirect short-run external effects, such as noise, environmental disturbances and reduction in amenity normally associated with construction activities (Nash, 1997).

Long-run direct economic effects include exploitation costs, in addition to transport costs and time benefits for people and freight accrued through the daily use of the infrastructure (Lakshmanan et al., 2001). Safety might also be improved considerably as a result of the project. These user benefits, in the main, are generally the prime reason for investing in infrastructure projects at any particular time (Boardman et al., 2006). There are also long-run indirect economic effects, such as the backward expenditure effects of the use of infrastructure, the reduction in transport cost for production and location decisions of people and firms, in addition to the subsequent effects on income and employment of population at large (Oosterhaven and Knaap, 2003). Not all of these effects, of course, are necessarily positive. Negative effects can result, for example, on account of the fact that the realisation of transport infrastructure projects has the potential to lead to greater net transport emissions, both of a greenhouse gas and a particulate nature. This can occur through the exploitation of the infrastructure (often associated with induced demand) and, admittedly to a much lesser degree, its maintenance (Richardson, 1999; Cervero and Hanson, 2002).

Table 1: Types of Effects of Transportation Infrastructure Investments

		Short-run	Long-run
Direct	via markets external effects	Construction effects Environmental effects	Exploitatation and time-saving effects Environmental, safety, etc., effects
Indirect	via demand external effects	Backward expenditure effects Indirect emissions	Backward expenditure effects Productivity and location effects Indirect emissions, etc.

Source: Adapted from Oosterhaven and Knaap 2003.

3. Literature Review on the Economic Impacts of Infrastructure

There is a large amount of literature on the economic impacts of infrastructure (e.g., Rietveld and Bruinsma 1998; Bhatta and Drennan, 2003; and Weisbrod and Reno, 2009), in addition to a wide array of methods used to estimate these impacts (Vickerman, 2000; Lakshmanan et al., 2001). The approaches most widely used can be identified as:

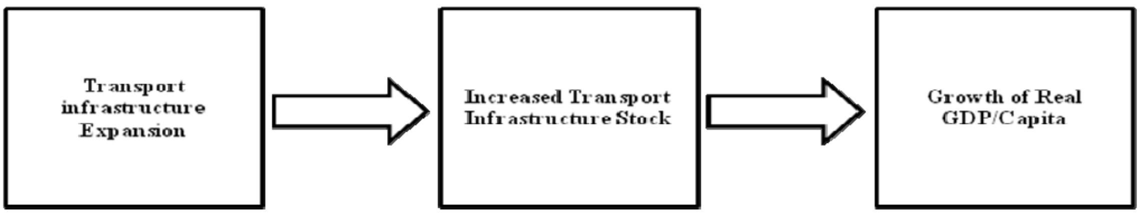
- Macroeconomic models;
- Microeconomic models; and
- Models of general equilibrium effects.

Below we will briefly review these three approaches.

3.1. Macroeconomic models

Many studies have tried to establish linkages between transport infrastructure investment and economic growth or GDP, with some indicating very substantial rates of return (e.g., Aschauer, 1989, Munnel, 1990). The most common approach is the *quasi production function* approach. This approach views infrastructure as a direct injection to the economy and estimates the contribution that infrastructure capital makes to private production (Sturm, 1998).

Figure 1: Infrastructure and Economic Growth



Source: Lakshmanan and Anderson, 2002.

Since the pioneering work by Koichi Mera (1973) in Japan, there has emerged a significant body of empirical work in the field. The classic work on the transport-economy linkages was undertaken in the United States by Aschauer (1989). He used an aggregate Cobb-Douglas production function and identified positive effects of transport investments on the economic growth experience in the 1949-1985 period. More recently, this macroeconomic analysis has been used in the United Kingdom to determine elasticities of productivity with respect to measures of agglomeration (Grahma, 2005 and

2006). Despite a broad agreement among the studies conducted in the United States and abroad with regard to the positive contribution of transport infrastructure to the overall economy, substantial debate has ensued regarding the magnitude of this contribution (DFT, 2005 and Banister, 2007).

A major deficiency of the macroeconomic studies, however, is that it tells us relatively little about the actual mechanisms through which these economic benefits arise. Policy formation must address not only the question of whether to invest in infrastructure, but also the question of which among an array of potential projects will yield the greatest economic return (Lakshamanan and Anderson, 2002). It is necessary to attribute economic benefits identified by the macroeconomic studies to specific mechanisms that may vary across projects and industries due to contextual factors. Nevertheless, macroeconomic approach still has significant potential, especially as a means to indicate the value of public spending on transport infrastructure (capital stock), and as a tool for identifying the optimum level of public spending on infrastructure.

3.2. Microeconomic models

In contrast to the macroeconomic approach, the microeconomic perspective tries to identify the link between specific infrastructure improvements and the productivity of specific production units. The conventional tool of the microeconomic perspective remains cost-benefit analysis, which is now widely used in the evaluation of major transport investment projects to ensure that they represent an efficient use of society's resources (Nash, 1993; Keegan et al., 2007). Most cost-benefit analysis evaluations, in the context of assessing the potential performance of transport infrastructure projects, concentrate on a limited range of benefits of transport interventions and generated traffic, i.e., lower vehicle operating costs, time saved by passengers and freight, and improved safety. It is assumed that these benefits induce more trips and thereby lead to economic growth (Lakshmanan and Anderson, 2002).

Cost-benefit analysis provides a useful framework to analyse these effects in a policy oriented context concerning investment decisions and pricing. That said, the method has some detractors (Vickerman, 2007). Indeed, the main criticism of an exclusive dependence on cost-benefit analysis is that economic impact is a broader measure of benefits. This is because economic impact should recognise not only economic growth benefits associated with direct cost savings and income generation benefits for transportation systems users, but also economic growth associated with expanding accessibility to markets(Cohen, 2007; Sue Wing et al, 2007). This issue is further complicated by the fact that cost-benefit analysis relies on assumptions of perfect competition, and may therefore undercount benefits in the face of imperfect competition (Venables and Gasiorek, 1999).

The existence of imperfect competition is especially the case for the transport sector, where service providers using the infrastructure (including the operators of the infrastructure itself) operate under different types of regulatory and access regimes depending on the sector. For example, in the case of intermodal freight in Australia, little in the way of regulatory commonality exists between road and rail, although both road and rail freight operators generally serve a common market (von der Heidt et al., 2009). Furthermore, access pricing differs markedly between road and rail, especially given that road freight has been argued to be subsidised, in effect, by other road users given that it results in greater maintenance costs and negative externalities compared to private vehicular transport using the same infrastructure (Laird, 1988).

3.3. General Equilibrium Approach

By focusing on the effects on individual firms, proponents of cost-benefit analysis have taken a partial equilibrium view. This discussion now shifts to the question of how the effects on individual firms redound through the entire economy, i.e., the general equilibrium view (Sue Wing et al, 2007). Some of the impacts of the transport system play themselves out over a long period of time and, as a result, can result in fundamental changes in the economic structure of the region in question. These impacts involve complex patterns of interaction between economic variables.

3.3.1. Computable General Equilibrium Approach

The Computable General Equilibrium (CGE) approach evaluates the physical and economic impacts of proposed expenditure plans in the near future by considering the direct impacts (transport user cost savings), in addition to the indirect benefits in other sectors of the economy. This is done by measuring the increased demand for goods and services used in other economic sectors (Broker, 1998; Venables and Gasiorek, 1999; Oosterhaven and Knapp, 2003). Despite this, CGE models are still experimental and their results, as a consequence, still need to be independently verified. In particular, significant variation in estimates can be produced using the same CGE model (OESR, 2002). This is because the flexibility of this model allows the analyst to incorporate his or her own professional judgment in determining the appropriate economic environment and initial project specification. Another disadvantage of CGE modeling is that substantial time and resources are required to develop a new model for analysis (Lakshmanan and Anderson, 2002). As a result, it may need improvement in the longer term if it is to be used in prioritising investment in infrastructure.

3.3.2. Input-Output Approach

To solve the problems of macroeconomic approach, cost-benefit analysis and CGE modelling, a structural equation approach within a concise and simple analytical framework is needed. The conceptual basis of this approach is an input-output model. Since the discussion above shows a broad variety of interactions taking place within sectors and between sectors, the impacts must be examined in a simplified general equilibrium fashion that is able to deal with linkages between sectors and within sectors. The main attraction of the input-output model is that it provides a very detailed picture of the structure of the economy at a particular point of time. It can therefore be used as a basis for the detailed analysis of inter-sectoral interrelationships within the economy (ABS, 2000). Moreover, input-output models can be made operational and accessible at lower cost in comparison with the more complicated CGE models.

Rose (1995) identifies several distinguishing features of input-output analysis. These are as follows:

- It is the simplest model for looking at economic activity in a production life-cycle context and is empirically verifiable.
- It is firmly grounded in the technological measurable relationships of production and bridges the gap between economists, managers and engineers.
- The sectoral layout facilitates data collection and data organisation.

- Input-output tables, in addition to Leontief multipliers, greatly facilitate the analysis of the impact of private-sector decisions and public-sector policies.

- The basic formulation of input-output tables is politically and ideologically neutral.

On account of its comprehensive but easy-to-understand description of complex economic systems, input-output analysis has been one of the major statistical tools for most economically important countries in the world over many years (Foran et al., 2005).

4. Australian Context for Transport Investment

In Australia, cost-benefit analysis is predominant in the transport-planning process (Dobes, 2008). Some examples are the relevant guidelines provided by the Australian Transport Council (ATC) 2006 National Guidelines for Transport System Management in Australia, jurisdiction-based guidelines[1], and other mode-specific guidelines, e.g., Austroads. These guidelines assess the potential change in economic welfare by considering the following parameters:

- Capital, operating and maintenance costs;

- Travel time savings, reductions in operating and accident costs; and

- External costs (such as air pollution, noise and greenhouse gases).

Infrastructure project evaluation requires policy-makers to consider the full range of potential impacts. With the exception of the direct cost and time savings captured in conventional CBA, our ability to measure any of the main categories of benefits described above remains poor (Gary, 2009). The head of Infrastructure Australia's[2] secretariat recently commented in the following terms about many of the infrastructure proposals submitted to that body: "the linkage to goals and problems is weak, the evidence is weak, and the quantification of costs and benefits is generally weak" (Infrastructure Australia, 2008). Infrastructure Australia has stressed that any project that it recommends for public funding must satisfy rigorous cost-benefit tests. Anthony Albanese, the current federal Minister for Infrastructure, Transport, Regional Development and Local Government has also affirmed that rigorous cost-benefit test includes quantification of the more 'subjective' social or environmental impacts, or, where this proves impossible, that there needs to be an explicit treatment of the nature of those impacts and the values imputed to them (Albanese, 2008).

Rubbery computations of this kind seem to be endemic to railway investments proposals, which have been seen to be optimistic on both the demand forecasts and the levels of costs (Infrastructure Australia, 2008). It is disquieting to observe, therefore, that rail projects feature heavily among the initial listing by Infrastructure Australia of projects warranting further assessment. In fact, the total amount of funding requested from the Commonwealth was well over $100 billion. Among these project proposals is a light rail system for the ACT and an even more ambitious high-speed rail (HSR) service linking Canberra with Sydney and Melbourne (Gary, 2009).

[1] Jurisdiction-based guidelines include the Queensland Treasury 2006 Cost-Benefit Analysis Guidelines, Victorian Department of Transport (DOT) 2007 Guidelines for Cost-Benefit Analysis, the NSW Treasury 2007, NSW Government Guidelines for Economic Appraisal.

[2] The role of Infrastructure Australia is to provide advice to the Minister, Commonwealth, State, Territory and local governments, investors in infrastructure, and owners of infrastructure on matters relating to infrastructure.

As a result of the prevalence of ambitious transport-related project proposals that could be subjected to what might well be described as optimistic revenue forecasts and conservative infrastructure provision costs (Flyvbjerg et al., 2003), there is a clear necessity to investigate this issue further. Such an investigation has the potential to allow a better estimation of the broader range of benefits accruing from transport-related projects and will help to ensure a more robust justification for approving such projects. This is particularly necessary in cases where it is clear that there is a high degree of risk attached to the realisation and operation of such projects. The key, it follows, is to be able to assess the economic benefits of infrastructure projects within a simplified coherent framework with greater accuracy, even if everything cannot be reduced to a single number, and even if some elements cannot be quantified.

5. Input-Output Models

This section of the paper applies input-output techniques so as to provide an appropriate framework for the economic impact analysis of different transport investment. Economic impact analysis using input-output techniques involves estimating the change in output (industry sales) and price in response to an actual or potential source of economic change in the economy. There are two methods of impact analysis, namely output estimation (changes in final demand of a particular industry) and price analysis (changes in values added or unit price of output of a particular industry). This study will focus on long-run economic impacts resulting from the development of new transport systems or the improvement of existing ones and examine them in detail by using two different measures, these being:

- Economic activity – incremental output (sales) generated by different transport modes.
- Price – impacts of reductions in transportation costs by different transport modes.

5.1. Data Source

The base table used for this analysis was the Australian Input-Output Table (indirect allocation of imports, basic prices, 109 industries), which was constructed by Australian Bureau of Statistics (ABS) for the 2004-2005 financial year. We aggregated the original Australian Input-Output Table into 30 industries in this analysis. As a result of the great amount of time and effort required with respect to gathering the data needed to build the table, the Input-Output Table for 2007-08 will not be available until 2012. Therefore, it is necessary to assume that the production structure of each industry has not changed significantly since 2004-05. This paper uses two hypothetical scenarios to demonstrate the economic implications of a $1 million change in final demand, together with a 10% reduction in transportation costs by different modes, resulting from new transport investment.

5.2. Output Estimation (Expansion of Existing Industries)

One approach to the economic impact analysis is an output estimation of incremental sales generated by the backward expenditure effects of the use of transport infrastructure (West and Jackson, 2005). This procedure involves replacing the final demand of the required sector by the actual monetary values. In this hypothetical scenario, the existing transport industry in the region was assumed to increase its output in order to meet additional transport services to final demand resulting from the new transport systems or improvement of existing ones. In our hypothetical scenario, new transport investment is assumed to result in a $1 million increase in final demand for different transport modes during the operational periods of the project.

Even though the initial demand impact is the same, there is considerate variation in the economic impacts between different transport modes. The degree to which a sector maintains backward expenditure effects provides an understanding of the capacity of the sector to stimulate economic activity across the broader economy. This is clearly important with respect to valuing properly the overall benefits of any planned investment in transport infrastructure projects. As shown in Table 2, the initial $1 million increase in final demand sales by the road, rail, water and air sectors results in a total increase in output in the economy of $2.898m, $2.957m, $2.939m and $2.547m respectively per annum.

Table 2 also breaks down the total impacts separately by industry sectors. Sectors in Australia benefitting the most from the backward expenditure effects of the road transport industry are finance, insurance and business services, trade services, and the communication services sectors. It is also estimated that the finance, insurance and business services, trade services, and construction sectors will experience the largest effects of the backward expenditure effects of the rail industry. In similar fashion, the finance, insurance and business services, trade services, transport NEC and petrochemicals sectors benefit most from the backward expenditure effects of the water and air transport sectors.

Table 2: Impacts of a $1m Increase in Final Output by Transport Modes

	Road transport	Rail transport	Water transport	Air transport
Animals	0.013	0.014	0.011	0.011
Crops	0.016	0.017	0.014	0.013
Forestry and fishing	0.004	0.006	0.004	0.003
Coal, oil and gas	0.028	0.020	0.021	0.037
Mining NEC	0.006	0.011	0.008	0.005
Food, drinks and tobacco	0.066	0.068	0.058	0.053
Textiles, clothing and footwear	0.008	0.009	0.007	0.006
Wood products	0.006	0.008	0.008	0.004
paper and publishing	0.035	0.040	0.034	0.027
Petrochemicals	0.076	0.033	0.048	0.116
Other chemical products	0.034	0.036	0.030	0.032
Non-metallic mineral products	0.007	0.013	0.007	0.005
Metals and metal products	0.027	0.101	0.039	0.020
Railway equipment	0.001	0.099	0.001	0.001
Other machinery and equipment	0.066	0.052	0.140	0.100
Manufacturing NEC	0.010	0.014	0.010	0.008
Electricity	0.032	0.058	0.041	0.024
Gas and water	0.021	0.018	0.019	0.012
Construction	0.037	0.113	0.038	0.028
Trade services	0.361	0.258	0.271	0.232
Accommodation, cafes and restaurants	0.065	0.061	0.057	0.048

Road transport	1.076	0.038	0.031	0.035
Rail transport	0.008	1.010	0.008	0.008
Water transport	0.003	0.002	1.028	0.003
Air transport	0.005	0.004	0.005	1.028
Transport NEC	0.043	0.034	0.258	0.100
Communication services	0.085	0.058	0.062	0.046
Finance, insurance and business services	0.610	0.625	0.551	0.440
Government services	0.084	0.072	0.065	0.053
Services NEC	0.065	0.065	0.063	0.050
Total	**2.898**	**2.957**	**2.939**	**2.547**

Source: Authors' calculation based on 2004-05 Australian Input-Output Table.

5.3. Price Analysis

As is generally known, the cost of transport as a percentage of total business costs varies from industry to industry (Fang et al., 1998). The actual pattern of business benefit (reduced travel costs) associated with transport projects could be very different. In this section, the impacts on unit prices in other sectors caused by changes in reductions of transport costs will be discussed. In our hypothetical scenario, new transport projects are assumed to result in a constant 10% reduction in transport costs by different transport modes during the operational periods of the project. The results are summarised in table 3 below.

Table 3: Impacts of a 10% Reduction in Transport Costs by Modes

	Road transport	**Rail transport**	**Water transport**	**Air transport**
Animals	-0.36%	-0.04%	-0.01%	-0.08%
Crops	-0.30%	-0.04%	-0.01%	-0.06%
Forestry and fishing	-0.28%	-0.04%	-0.04%	-0.07%
Coal, oil and gas	-0.08%	-0.26%	-0.02%	-0.04%
Mining NEC	-0.14%	-0.07%	-0.08%	-0.12%
Food, drinks and tobacco	-0.57%	-0.07%	-0.02%	-0.11%
Textiles, clothing and footwear	-0.14%	-0.05%	-0.01%	-0.08%
Wood products	-0.51%	-0.04%	-0.02%	-0.09%
Paper and publishing	-0.19%	-0.04%	-0.02%	-0.15%
Petrochemicals	-0.10%	-0.19%	-0.15%	-0.05%
Other chemical products	-0.21%	-0.07%	-0.02%	-0.10%
Non-metallic mineral products	-0.63%	-0.19%	-0.04%	-0.09%
Metals and metal products	-0.28%	-0.17%	-0.06%	-0.10%
Railway equipment	-0.21%	-0.06%	-0.02%	-0.08%
Other machinery and equipment	-0.11%	-0.03%	-0.01%	-0.07%
Manufacturing NEC	-0.35%	-0.05%	-0.02%	-0.10%
Electricity	-0.14%	-0.34%	-0.03%	-0.11%
Gas and water	-0.11%	-0.04%	-0.01%	-0.14%
Construction	-0.29%	-0.06%	-0.02%	-0.10%
Trade services	-0.18%	-0.04%	-0.02%	-0.21%
Accommodation, cafes and restaurants	-0.26%	-0.04%	-0.01%	-0.10%
Road transport	-10.00%	-0.05%	-0.03%	-0.10%
Rail transport	-0.18%	-10.00%	-0.02%	-0.07%
Water transport	-0.15%	-0.04%	-10.00%	-0.13%

Air transport	-0.13%	-0.04%	-0.02%	-10.00%
Transport NEC	-0.19%	-0.05%	-0.01%	-0.16%
Communication services	-0.18%	-0.06%	-0.03%	-0.18%
Finance, insurance and business services	-0.06%	-0.03%	-0.01%	-0.15%
Government services	-0.12%	-0.02%	-0.01%	-0.16%
Services NEC	-0.18%	-0.03%	-0.02%	-0.17%

Source: Authors' calculation based on 2004-05 Australian Input-Output Table.

Table 3 indicates that price changes in other industries as a result of a 10% reduction in the road transport cost range from 0.63% to 0.06%. Sectors with the highest price effects are non-metallic mineral products, food, drinks and tobacco, and wood products. For a 10% reduction in the rail transport costs, it is estimated that price changes in other industries are ranged from 0.34% to 0.02%. It is clear that the electricity, coal, oil and gas, and non-metallic mineral products sectors are most affected by transport improvements.

Price changes in other industries as a result of a 10% reduction in the water transport industry are ranged from 0.15% to 0.01%. Industries benefitting the most from the reduction in transport costs are petrochemicals, mining NEC and the metals and metal products sectors. The impact of a 10% reduction in air transport costs are also felt in other sectors of the economy, ranging from 0.21% to 0.04%. The sectors with the highest price effects are trade services, communication services and services NEC.

In this hypothetical example, the effects of transport cost reductions are felt far beyond the various transport sectors. By comparing table 2 with table 3, it is evident that the ultimate effects of transport projects of price changes on other sectors may not necessarily reflect the same pattern of final demand changes on business output. In view of these results, it becomes important to understand the competitive context of industries affected by transport projects. Estimation of economic impacts that simple equates cost reductions impacts with business output impacts, may be subject to substantial error.

5.4. Limitations of the Study

There are a number of important assumptions in the input-output model that should be considered when interpreting the analytical results. These can be summarised as follows (Dixon et al, 1992; ABS, 2000).

- Industries in the model have a linear production function, which implies constant returns to scale and fixed input proportions.
- The firms within a sector are homogeneous, which implies they produce a fixed set of products that are not produced by other sectors and that the input structure of the firms are the same.
- The model is a static model that does not take account of the dynamic processes involved in the adjustment to an external change.

6. Summary

The economic impacts of transport systems are pervasive and complex. As a result, it is important for local, state, and federal decision-makers to identify the appropriate level of spending for transport infrastructure and fund the most appropriate projects in order to maximise broader social benefits. As this paper has argued, macroeconomic studies tell us relatively little about the actual mechanisms through which the economic benefits associated with transport projects arise. Although conventional CBA is clearly a useful tool, its scope is arguably limited. Moreover, conventional CBA used to value transportation user benefits and economic benefits for specific transport projects, based on simple calculations of savings in travel time and vehicle operating expenses, can understate total project impacts as a result of missing other important aspects of productivity enhancement.

The challenge for transport infrastructure assessment and planning, however, is to adequately reflect the magnitude of business cost savings and productivity increases when estimating the benefits of new transport projects. Such benefits can be much more than just simple times savings resulting from the faster trips, as is generally estimated from conventional cost-benefit analysis. This research focuses on a unified price and monetary input-output model and investigates the ways in which the application of this model can be extended so as to explore the effects of investment in transport infrastructure projects in a policy analysis context. In particular, the results presented herein show that a multi-sectoral input-output model can capture the sectorally different nature of the primary impacts of transport infrastructure. In addition, exogenous cost reduction impulses can also be calculated in such a way that the sectorally different impact on domestic prices will be sufficiently captured.

In sum, while it is clearly not practical to engage in sophisticated modelling for all of the elements of economic impact for every project, it is nevertheless important and possible to recognise the breadth and nature of potential impacts during the decision-making process. Given our degree of uncertainty about many of these benefits, further research along two avenues is warranted. The first is the further elaboration of CBA to capture the effects of productivity-enhancing effects and value-added effects. Another potential avenue is the development of more comprehensive frameworks such CGE models to include a broader range of economic mechanisms.

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Appendix

Input-Output Quantity Model

Based on the input-output table, one can derive the matrix of input-output coefficients, the so-called technical coefficients, by dividing the matrix of x_{ij} by total outputs x_j

$$a_{ij} = x_{ij} / X_j \quad (1)$$

Express the n × n matrix of a_{ij} as A, which is called the technical coefficients matrix. The technical coefficient represents the share of input from each sector required to produce on unit of sectoral output. As a consequence, the general equation for this input-output model is:

$$X = (I + A + A \times A + A \times A \times A + \ldots)Y = (I - A)^{-1}F \quad (2)$$

Where X; n×1 vector of sector outputs, I; n×n identify matrix, F; n×1 vector of final demands. In this equation, the terms represent the total input required by final demand itself ($I \times F$), contributions from the first level direct supplier ($A \times F$), the second level indirect supplier ($A \times A \times F$), etc. The complete input required by final demand is expressed by this infinite series of the supply chain, which can be substituted by $(I - A)^{-1}$.

Input-Output Price Model

Even if monetary units are used, the quantity input-output model cannot deal with price issues. Therefore, the price model is developed based on the same balance data, represented by the following equation.

$$(I - A')p = V \quad (3)$$

where p is n×1 vector expressing the unit price of output in each sector, V is also n×1 vector representing the value-added of each sector. For sectors whose outputs are measured in monetary units, e.g., business services, the corresponding unit price in vector p is simply 1.0. This equation can be used to compute impacts on unit prices caused by changes of technology coefficient (A) and value-added of each sector (V).