IO Based Impact Analysis: A Method for Estimating the Economic Impacts by Different Transport Infrastructure Investments 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 revitalize Australia's increasingly inadequate land transport infrastructure. There has been much controversy, however, over whether such investments are efficient, or whether public funds are better spent on other projects. It is clear that, for the investment of public funds to have the greatest positive effects, government agencies need to find 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 large costs.

This paper investigates the impact of alternative investments in road, rail, water and air transport infrastructure in Australia by using an input-output framework. It utilizes 2004-05 ABS national input-output tables as a database for a transport-oriented input-output model of the Australian economy. The analysis involves two steps: one is run for the price model, and the other for the quantity model. These results are then compared across the various transport sectors. Scenario results show that, despite some limiting assumptions, 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 Model

1. Introduction

The Australian land transport system, which primarily consists of roads and rail, is becoming increasingly congested, while 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 revitalizing 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 decisions are usually highly politicized. 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 of a general retreat in the Western world from 'big government', a move which has widely resulted in the sale of public assets, including those able to generate revenue (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 realizing 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 the 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). Yet 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 can 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., 2010; 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, CBA and environmental impact assessments (IAS) are typically required for investments in infrastructure (ATC, 2006). However, the economic impact analysis (EIA) has remained underexposed in ex-ante transport project appraisals. Although the Input-Output (I-O) framework is commonly used by agencies internationally, it has failed to attract much attention in Australia on account of its controversial assumptions, such as linearity properties and lack of price effects. In order to promote a move towards redressing these issues, this paper attempts to employ a modified input-output model to describe empirically the impacts of various transport infrastructure investment. The research as presented herein therefore has three broad and interrelated goals:

- To recap briefly the issues related to the assessment of economic impacts from transport infrastructure projects;
- To examine empirically the impacts of various transport infrastructure investment based on our review of alternative methodologies available; 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 transport extended I-O modelling is then used to illustrate the impacts of alternative investment in road, rail, water and air transport infrastructure in a policy analysis context.

2. A Taxonomy of Economic Impacts

Although transport networks, and indeed improvements to that network, do not in isolation necessarily result in increases in economic growth, they have a circular impact on the ability and outcomes of growth (Lakshmanan and Anderson, 2002). However, there is considerable debate among transport professionals, scholars and researchers regarding what constitute an ‘economic impact’. A good place to start is by organizing the potential impacts into categories; that is, creating a taxonomy of benefits (Weisbrod, 1997). This research will therefore assign impacts 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 impacts. Short-run economic effects will occur during construction, directly and indirectly through demand effects, such as the demand for 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. In the main, these user benefits 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 these effects, of course, are necessarily positive. Negative effects can result, for example, on account of the fact that the realization 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	Construction effects	Exploitation and time-saving effects
	external effects	Environmental effects	Environmental, safety, etc., effects
Indirect	Via demand	Backward expenditure effects	Backward expenditure effects
	external effects	Indirect emissions	Productivity and location effects
			Indirect emissions, etc.

Source: Adapted from Oosterhaven and Knaap 2003.

This investigation will focus on long-run cost saving effects and associated backward expenditure effects in response to new transport infrastructure investment.

3. Literature Review on the Economic Impacts of Infrastructure

There is a large amount of literature dealing with the economic impacts of infrastructure (see, 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.

Before reviewing these approaches, a set of criteria needs to be established in order to examine each method against these criteria. The following four principles represent universally accepted features of good analytical method and study designs (Selltiz et al., 1976; Chadwich et al., 1984). Methods used for estimating the economic impacts of transport investment can be evaluated based on these four principles or criteria. The methods reviewed in this study are rated according to how they fare regarding these criteria.

- **Reliability** – the method must provide consistent and stable results when applied repeatedly to the same case or cases.
- **Disaggregate** – the impact of travel cost savings will vary across sectors in the economy, depending on the sectoral intensity of transportation use; as a result, the selected framework must allow the analysis to be performed at disaggregated levels.
- **Transparency** – these approaches must indicate the degree to which methods, assumptions, and results are understood and accessible to an audience beyond those interested in methodology.
- **Data requirement** – the availability of data is a challenge in any empirical study, so the methods reviewed for this study must employ publicly available information.

Below we will briefly review the three aforementioned approaches.

3.1. Macroeconomic Models

Many studies have tried to establish links 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.

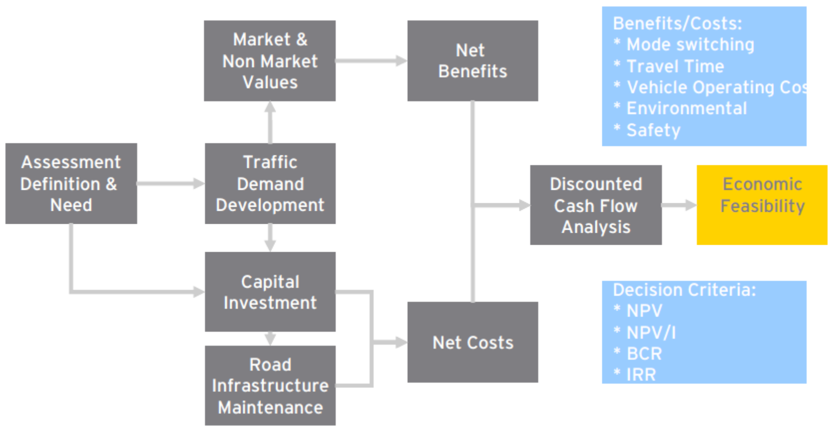
Since the appearance of the pioneering work of Mera (1973) in Japan, there has emerged a significant body of empirical work in the field. The classic work on the transport-economy linkages was undertaken in the United States by Aschauer (1989). He used an aggregate Cobb-Douglas production function and identified positive effects of transport investments on the economic growth experienced between the years 1949-1985. 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 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 project from a field of possibilities will yield the greatest economic return (Lakshamanan and Anderson, 2002). Furthermore, it is necessary to attribute economic benefits identified by the macroeconomic studies to specific mechanisms that may vary across projects and industries on account of the various contextual factors. Nevertheless, the 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 (CBA), 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). Many of the potential economic benefits of a transport investment stem from reductions in travel times (for passenger and freight), which are determined by using travel demand models. The reduction in travel time and other improvements in the transportation system's performance (i.e., safety benefits and changes in transportation operating costs) are assigned monetary values (see Figure 2). These costs savings represent direct user benefits, and historically comprise the numerator of the benefit-cost equation (Lakshmanan and Anderson, 2002).

Figure 2: Standard Approach to Cost-benefit Analysis



Source: VIC Department of Transport, 2010

CBA is a widely accepted method for evaluating the economic impact of transport projects. It is one of the best tools available to determine if society will be better off economically if the project goes ahead. With respect to its positive aspects, CBA not only enables us to express an opinion on the economic-social convenience of a project, but also enables the ranking of various project proposals (Brent, 1996). On the negative side, CBA can also be easily misused to overstate the benefits associated with a transport project (Belli et al, 2001). Indeed, one of CBA's limitations is that it does not take wide economic impacts into consideration, which occur over and above the direct benefits that accrue to users of the transportation system (Banister, 2007). Moreover, CBA is particularly sensitive to changes in the discount rate used to calculate the value of costs and benefits over time, as well as to the analysis period used for the investment scenario. [1] This sensitivity is a major disadvantage of this method in the context of assessing transport projects (Shofield, 1989). Even at low discount rates, CBA is biased against the long-term impacts of transport investment and will tend to favour highway investment, which generally results in more short-term benefits (TCRP, 1998).

Finally, the issue is further complicated by the fact that CBA relies on the assumption 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 in 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 that vary considerably depending on the sector and indeed the jurisdiction (see, e.g., Laird 1988 and von der Heidt et al., 2009).

For all these reasons, CBA might be considered a useful tool for evaluating and selecting projects, but it arguably requires strict methodological coherence in its application.

3.3. General Equilibrium Approach

By focusing on the effects on individual firms, proponents of CBA 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 et al., 2007). Some of the impacts of the transport system play themselves out over a long period of time and, as a consequence, 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. Input-Output Approach

Input-output (I-O) method is used to enumerate inter-industry production and linkages that occur as a consequence of increased demand and consumption within a particular sector, such as transport. I-O models typically use regression equations to associate purchases of goods or services in one industry with similar purchases in other sectors (Miller et al, 1985). Transport facility construction, for example, would create increased production, consumption, and employment in the fabricated metals and stone/glass/clay industries, two industries which are suppliers to the construction industry. Inputs into the model include the dollar amount spent in different industries to construct, operate and maintain a new transportation system. The model estimates the dollar value of direct, indirect and induced production by industry resulting from the spending.

I-O models can also trace the effects of travel cost reductions as they ripple through the regional economy. In this kind of analysis, the input to the model is the dollar value of the travel costs savings (which are derived from estimates of travel time savings, safety benefits, and changes in operating costs) for industries that will benefit from a transport investment

[1] Acceptable discount rates, analysis periods and values for travel time and safety benefits are often established on a state-by-state basis, and must be appropriate to the geographic area under study.

(see, e.g., Strathman, 1987 and Forkenbrock et al. 1990). The advantage of the I-O technique is its ease of use and transparency (West, 1995; OESR, 2002). Those employing the technique can make use of readily available I-O tables since government statistical bureaux in most countries periodically produce such tables. Another attraction is that the model provides a very detailed picture of the structure of the economy at a particular point of time and makes analysis at disaggregated levels possible. Finally, I-O analysis is politically and ideologically neutral (Foran et al., 2005). This is because it does not incorporate any specific behavioural conditions for the individual, companies, or indeed the state.

However, as a methodology for undertaking economic impact analysis, the ease of use comes at a certain cost. In particular, I-O models are easy to use because of a number of limiting assumptions. One major limitation of the model when used to conduct impact analysis is the use of fixed coefficients, which imply that an industrial structure remains unchanged by the economic event. Another major limitation is the model's lack of supply-side constraints. Constraints on the availability of inputs, such as skilled labour, require some means, e.g., prices, to act as a rationing device so as to induce changes in the consumption patterns of producers and consumers. In I-O analysis, where all adjustments take place in changes in the quantities produced, this type of rationing response is assumed not to occur (West, 1995 and 2005). Nevertheless, because of its comprehensive but easy-to-understand description of complex economic systems, the I-O method has been one of the major statistical tools for most economically important countries in the world over many years (Foran et al., 2005).

3.3.2. Computable General Equilibrium Approach

The Computable General Equilibrium CGE model is another model that is receiving increased attention from transport researchers. In contrast to I-O models, the CGE model is an optimization model, i.e., it provides the 'optimal' solution mix of endogenous variables in response to an exogenous shock (e.g., Broker, 1998; Venables and Gasiorek, 1999; Oosterhaven and Knapp, 2003). In addition, unlike the I-O model, which is demand driven, the CGE model contains explicit supply constraints, usually embedded in a neoclassical framework.

In essence, unlike the I-O model, each flow in the I-O table is split into two components, i.e., quantity and price, when the CGE approach is employed. These are often expressed in the form of composite goods and prices. Prices are determined endogenously (Hertel and Tsigas, 1997; Lofgren et al, 2002). Each intermediate column of the I-O table is described by a multi-level or nested production function, usually Leontief, Cobb-Douglas or constant elasticity of substitution (CES), while inputs into the production system are determined by a cost minimization or utility/output maximization procedure. Unlike the I-O model, which achieves equilibrium in supply and demand quantities only, the solution to the CGE model is given through both quantities and prices (West, 1995).

The CGE model naturally has its own pros and cons. The main benefit is that the supply side (as well as the demand side) is now explicitly determined with full price response. Yet the degree to which neoclassical general equilibrium theory is generally applicable depends largely on the strength of the small country assumption, particularly at the regional level,. Unfortunately, although the CGE model is probably more theoretically satisfying than other approaches, especially given that it conforms better to microeconomic theory, a different story may present itself when the model is considered empirically. Its implementation necessitates the specification of a large number of parameters and coefficients, which are generally not available (West, 1995; Panagariya and Duttagupta, 2001). For example, the ORANI-NT model (based upon ORANI, a widely used Australian model developed by Peter Dixon in the 1970s) comprised more than 7983 variables in 3249 equations. As a result,, 'best guess' values must be used, which inject a large unknown element into the model (West, 1995 and 2005). Evidence suggests that this unknown factor can have a significant effect on the empirical results (Rose, 1995; McKitrick, 1998). Another disadvantage of CGE modelling is that substantial time and resources are required to develop a new model for analysis (Lakshmanan and Anderson, 2002). For example, the Monash model, which used ORANI as its base, took nine years to develop. On account of these constraints, the approach may need improvement in the longer term if CGE modelling is to be used in prioritizing investment in various transport infrastructures.

3.4. Summary

The review of economic impact studies shows that all methods – cost-benefit analysis, macroeconomic, CGE and I-O models have their strengths and weakness. Their strengths or weakness are summarised in Table 2 in accordance with certain criteria outlined before.

Table 2: Economic Impact Methods: Key Features

Criteria	Cost-benefit Analysis	Macro Models	I-O Models	CGE Models
Reliability	Medium/High (✓)	Medium (✓)	Medium (✓)	Medium(✓)
Disaggregate	No (✗)	No (✗)	Sectoral (✓)	Sectoral (✓)
Transparency	Medium/High (✓)	Low/Medium (✗)	Medium/High (✓)	Low/Medium (✗)
Data requirement	Medium (✓)	Medium/High (✗)	Medium (✓)	Medium/High (✗)

Note: Symbols in parentheses represent the compatibility with criteria outlines before.
"✓" denotes compatible, while "✗" denotes incompatible

Of the reviewed approaches, the I-O method satisfied all the criteria established previously in this paper. Some points in support of this selection are noted below.

- An I-O approach can estimate both macro-economic changes and industry-specific changes (e.g., employment, income, productivity) stemming from the construction, operation and maintenance of a transport system, and/or from business cost savings that the system produces. The I-O approach to the transport sector can be reproduced in every country, for almost any base year, and by any institution, since input-output tables are generated and published in regular intervals by statistical bureaux around the world.

- The I-O approach is also an appropriate method for analysis at disaggregated levels of the economy. The user can further disaggregate the published input-output tables to the level of detail required for analysis.

- Details of the I-O models are not highly complex, and communicating the impact results is not difficult.
- With regard to data requirements, the I-O approach has an advantage over other methods since. Information required for the analysis can be obtained from national statistical bureaux.

While we recognize the limitations of the I-O approach, it is selected as the framework to be used in the following analysis on account of its above-mentioned useful attributes.

4. Australian Context for Transport Investment

In Australia, CBA 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[2], 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 secretariat[3] 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 CBA 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, in addition to the values imputed to them (Albanese, 2008).

Rubbery computations of this kind seem to be endemic in 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

[2] 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.

[3] 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.

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 (REF). 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. It will also 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 realization and operation of such projects. The key, it follows, is to be able to assess the economic impacts of infrastructure projects within a valid, disaggregate, transparent and data-friendly framework, even if everything cannot be reduced to a single number, and even if some elements cannot be quantified.

5. Input-Output Analysis

This section applies I-O techniques so as to provide an appropriate framework for the economic impact analysis of different transport investment. There are two methods of impact analysis, viz., price analysis (changes in values added or unit price of output of a particular industry) and output estimation (changes in final demand of a particular industry) in response to a potential source of economic change in the economy. This study will focus on i) new transport investment changes the transport costs of business and therefore affects the price level of outputs of various sectors, and ii) existing industry expands from changes in final demand for the transport input generated by business cost savings and examine them in detail by using two different measures, these being:

- Prices – impacts of exogenous change in transport input prices in response to new transport investment throughout the economy.
- Economic activity (expansion of existing industries) – incremental output (sales) of industries that will benefit from a transportation investment.

5.1. Methodology and Data Source

The analysis involves two steps: one is run for the price model, and the other for the quantitity model. For the price model, the analysis is run by stimulating that the price of transport input would has been 10% below their actual level in response to a new tranport infrastructure investment. For the quantity model, demand for this transport input would have been $1 million above the actual level generated by business cost savings resulting from the new transprotation investment (Figure 3).

Figure 3: Diagram of the Methodological Framework

5.1.1 Assessment of Price Impact

In the first module, we assume that new transport investment would lower the costs of transport inputs for business and therefore affect the price level of the outputs of other sectors. A hypothetical scenario prices levels will be obtained as a consequence of the introduction of the new transport investment. These sectoral price effects are estimated using the input-output price model. The change in these prices can be determined from Equation 3.

$$P = (I - A')^{-1} V \tag{3}$$

Equation 3 is the standard Leontief's I-O price model. This equation can be used to "assess the impact on price throughout the economy of an increase in value-added costs in one or more sectors" (Miller & Blair 1985, p.356). More importantly, the impact of change in the cost of a particular product on other sector prices can be analysed within the I-O model. This can be done by exogenously specifying product prices and excluding them from the traditional Leontief's price model. For instance, the impact of change in transport service price P_T on other sector prices P_O can be analysed by assuming P_T as exogenous and estimating P_O endogenously. As a result, Equation 3 can be separated into exogenous and endogenous components.

$$\begin{bmatrix} P_T \\ P_O \end{bmatrix} = \begin{bmatrix} A'_{TT} & A'_{OT} \\ A'_{TO} & A'_{OO} \end{bmatrix} \cdot \begin{bmatrix} P_T \\ P_O \end{bmatrix} + \begin{bmatrix} V_T \\ V_O \end{bmatrix} \tag{4}$$

With P_T omitted from the traditional price model, in order to find P_O, Equation 4 can be written as:

$$P_T = A'_{TO} P_T + A'_{OO} P_O + V_O \tag{5}$$

Equation 5 can also be written as:

$$P_T = [(I - A'_{OO})^{-1} A'_{TO} P_T] + [(I - A'_{OO})^{-1}] V_O \tag{6}$$

Equation 6 can be used to assess the impact of changes in price of one or more sector throughout the economy.

5.1.2. Economy-wide Impact

In the second module, we translate those hypothecial business cost savings into businss demand changes for transport servcies and then apply the I-O model so as to trace how the impact would be distributed among different sectors.The economy-wide impacts are analysed using the transport-oriented input-output framework specifically developed for this study. The economic wide impacts of travel cost savings are determined and quantified in terms of changes in sectoral output/production. The starting point for this analysis of economic impacts is the basic input-output identity, namely

$$X = (I + A + A \times A + A \times A \times A + \ldots)Y = (I - A)^{-1} F \qquad (8)$$

Where

X: n×1 vector of sector outputs,

I: n×n identify matrix,

F: n×1 vector of final demands.

A: n × n matrix of technical coefficients.

Equation 8 can be directly applied for the extension of energy, environmetnal and social attributes. On account of the time and resource constraints, this study only focuses on the output impacts.

5.1.3. Data Source

The aggregated version of the 2004-05 tables with 30 sectors is used to stimulate the economic impact of a 10% reduction in transport input costs together with a $1-million change in final demand with regard to the various transport sectors. This table has been compiled on the basis of the Australian Input-Output Table 2004-05 (ABS, 2009, Cat 5215). All tractions recorded in the table are expressed at basic prices. The original 2004-05 table was compiled with 109 industry sectors; however, for the sake of simplicity, the aggregated version of this table is employed in this study. It is worth noting that, in the aggregated version of this table, the most specific sectors relating to the transport sector are “road transport”, “rail transport”, “water transport” and “air transport”. 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. Had there been a 2007-08 table, we could have produced more accurate results. However, the results obtained are still useful from a policy perspective since the production structure of each industry has not changed significantly since 2004.

5.2. Price Analysis

The implementation of a new transport project is assumed to lower the transport costs of business and also affect the price of various sectors. Such price changes would depend on the intensity of transport inputs into the provision of these goods or services. For example, sectors with intensive transport inputs would logically have higher positive impacts than those with less transport-intensive inputs. In our hypothetical scenario, a new transportation project is assumed to lower transport input costs by 10% below their actual level as a response to the new investment. The figures in Table 3 outline the impact of transport input price shock as a percentage change in prices of the outputs of various sectors.

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

	Road	Rail	Water	Air
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	-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%

Note: The acronym NEC stands for “not elsewhere classified”.
Source: This table shows the results obtained by the application of Equation 6 based on 2004-05 Australian Input-Output Table.

Table 3 indicates that price changes in other sectors as a result of a 10% reduction in the road transport cost range from 0.63% to 0.06%. The sectors with the highest price effects are the non-metallic mineral products, food, drinks and tobacco, and wood products sectors. For a 10% reduction in the rail transport costs, price changes in other sectors are estimated to range 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. Price changes in other sectors as a result of a 10% reduction in the water transport industry range from 0.15% to 0.01%. Sectors with the most significant impacts are the 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.

The operation of different transport infrastructure would result in a change in prices for the outputs of various sectors. Such a change would depend on the transport input intensity of that sector on the transport sector. The results suggest that the resource and energy sectors (mineral products, electricity and petrochemicals sectors) are susceptible to price change with respect to rail and water transport inputs. The agricultural sectors and the food, wood and animal sectors in particular, would also become more susceptible to any price change in road transport inputs. The change in prices of the outputs of these sectors is much higher than the change that would take place in the case of any price change of other alternative transport modes. This is because these sectors consume a greater amount of road, rail and water transport inputs in order to undertake their sectoral activities.

5.3. Economic Activity

Another approach to the economic impact analysis is to translate those hypothecial business cost savings into business demand changes for transport servcies and then apply the I-O model in order to trace how the impact would be distributed among different sectors. In our hypothetical scenario, a new transport investment is assumed to stimulate a $1 million increase in final demand for different transport services.

Even though the initial demand impact is the same, there is considerable variation in the economic impacts between the 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 impacts of any planned investment in transport infrastructure projects. As shown in Table 4, 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 4 also breaks down the total impacts separately by industry sectors. The sectors in Australia expanding most significantly from the backward expenditure effects of the road transport industry are the 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 would benefit most from the backward expenditure effects of the water and air transport sectors.

Table 4: Impacts of a $1m Increase in Final Output by Transport Modes

	Road	Rail	Water	Air
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	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	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**

Note: The acronym NEC stands for “not elsewhere classified”.

Source: This table shows the results obtained by the application of Equation 8 based on 2004-05 Australian Input-Output Table.

In sum, new transport investment would mainly affect the outputs of services sectors. For example, in this case, the total output of the financial, insurance and business services and trade services sectors would increase significantly as compared with the output in the other sectors.

In the two hypothetical scenarios, the impact of changes in exogenous price and final demand changes in the transport sectors are felt far beyond the transport sectors. By comparing Table 3 with Table 4, it is evident that not all sectors of the economy would be equally affected. In view of these results, it becomes important for policy makers to develop a greater understanding of the competitive context of industries affected by transport infrastructure investments. Transport infrastructure delivery is clearly essential, but the benefits of such investment vary significantly among various sectors.

5.4. Validation of Multipliers

A literature search uncovered no other estimates of price change that would provide a meaningful comparison to the estimates in this study. The validity of the results reported in Table 3 and Table 4 were tested by comparing the output multipliers estimated in other studies with other previous studies including those obtained from the CGE model. It is difficult to compare the estimated results of I-O and CGE modelling since the assumptions underpinning these models vary significantly. The multiplier estimates in the other columns were collected from a range of other studies that looked at regional Australia and Australia as a whole. Some of these studies focused on a single industry, and others reported multiplier estimates for a range of different sectors.

Despite the preceding words of warning, it was interesting to observe the following findings. First, the output multipliers associated with the transport were all higher than those multipliers produced from Johnson's studies of the Kimberley and Western Australian economies. This is as expected, since multipliers that relate to large regions are typically larger than those relating to small regions, where imports tend to be relatively high. Second,, Victoria and national CGE multipliers are also smaller than their I-O counterparts, mainly because the former arise from models containing resource constraints and price responsive behaviour.

Table 5: Comparison with Multiplier Estimates from Other Studies

Stoeckl et al (2007)	Johnson (2004)	Johnson (2004)	ABS Input-Output Table 2004-05	ABS Input-Output Table 2004-05	MRF model 2008	ORANI model 1995
Transport	Transport	Transport	Road	Rail	Road	Road
1.4	2.11	2.42	2.90	2.96	1.42	1.6

Results reported in Tables 3 and 4 measures transfer impacts, usually in terms of inter-industry outputs by industry sector. They can also provide impacts in terms of employment and household income. The most interesting contribution of tables 3 and 4 relates to impacts on sectoral distribution. Knowledge of the impact of sectoral demand may prove to be important, particularly given that some sectors must be stimulated in order to accelerate the growth rate (West, 2005).

5.5. Limitations of the Results

As a methodology for undertaking economic impact analysis, the ease of use comes at a cost. There are a number of important assumptions in the input-output model that should be considered when interpreting the analytical results of tables 3 and 4. Since I-O models focus only on the interactions of industrial segments, they exclude other potentially significant economic impacts. For example, if a transport investment reduced average household travel and vehicle operating costs, consumers would have additional disposable income, and would return some of that income back to the economy in the form of increased spending. Given that I-O models do not simulate the behaviour of individuals or households, it fails to account for these kinds of benefits (West, 1995).

Another limitation of I-O models is that they are static. I-O models alone can estimate the impacts of changes in flows of money, but not the dynamics of business expansion over time resulting from changes in business cost. It also does not account for long-term economic, industrial and demographic changes or for changes in business costs over time. As a consequence, I-O models produce results that are only valid for fixed points in time (Rose, 1995; West, 2005).

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 maximize broader social benefits. The forgoing discussion underscored the importance of having a valid, disaggregate, transparent and data-friendly framework for a transport sector with respect to analysing the impacts of an exogenous change in the economy.

This research focused on an I-O model and investigated empirically the ways in which the application of this model can be extended so as to explore the impacts of investment in transport infrastructure projects in a policy analysis context. The analysis involved two steps: one was run for the price model and the other for the quantitity model. The exogenous price shock in the rail and water transport sectors resulted in a significant change in sectoral prices in the resource and energy sectors throughout the economy. This reflects the high dependence of these sectors on the rail and water transport sector. Another significant finding is that the agricultural sectors, in addition to the service sectors, were among the sectors that would experience significant changes in sectoral prices in the event of a change in the road and air transport input prices. Similarly, not all sectors of the economy would be equally affected in terms of incremental outputs. New transport investment would mainly affect the outputs of service sectors. In particular, the total output of the finance insurance and business services and trade service sectors would increase significantly compared with the output in other sectors. In view of these results, it becomes important for policy makers to develop a greater understanding of the competitive context of industries affected by transport infrastructure investments.

The conventional I-O models are the simplest approach, both in construction and implementation, and are still widely used for economic impact analysis, but the limitations, such as linearity properties and lack of price effects, are also widely recognized. It is reasonable to say that, to some extent, I-O models overestimate the static flow-on effects of an impact or shock to the economy. It is for these reasons that alternative and more complex models are being designed and built. Nevertheless, I-O models have a clear use as a descriptive tool with regard to the impacts on sectoral distribution, and are certainly indispensable as a base for many extended models, in addition to more complex modelling procedures.

While it is clearly not practical to engage in sophisticated modelling for all of the elements of economic impact associated with every project, it is nevertheless important to recognize the breadth and nature of potential impacts during the decision-making process. Given the acknowledged degree of uncertainty about many of these benefits, further research is warranted. One potential avenue is to retain the detailed sectoral disaggregation of the I-O system and close it using a system of endogenous econometric relationships, generally expressed in elasticity form estimated from time series or panel data. By incorporating econometric relationships, new I-O models have the potential to address the shortcomings of linearity assumption in the production system and lack of market feedback mechanism between primary factors and final demands in simple I-O analysis.

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