The Potential Impacts of High Speed Rail on Regional Economic Development in Australia: Towards a Multiregional Input-Output Approach

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Summary

Estimating the economic impacts of high speed rail (HSR) on regional development is a largely unresolved issue. This paper will provide an overview of the basic issues, the contributions of empirical literature, the modelling approaches used until now, a multiregional framework and how that might be applied in an Australian context. The proposed multiregional framework focuses on the inter-industry relationship and the assessment of changes on a transportation network, with the analytical methods employed being twofold: a multiregional input-output (IO) model and a transportation accessibility evaluation index. By using this analytical framework, the economic impacts from developing an Australian HSR system can be estimated and evaluated on hypothetical scenarios relating to any future HSR project.

Keywords: multiregional IO model, accessibility index, regional development

1. Introduction

The important role of transport infrastructure for regional development is one of the fundamental principles of regional economics. In its most simplified form, it implies that regions with better access to the locations of input materials and markets will, *ceteris paribus*, be more productive, more competitive and hence more successful than more remote and isolated regions (Munnell, 1992). However, the relationship between transport infrastructures, High Speed Rail (HSR) and economic development in particular, seems to be more complex than this simple model would suggest. The regional impacts of HSR in European and Japan confirm the theoretical expectation that accessibility to a transport network matters (Bonnafour, 1987; Sasaki et al., 1997). That said, there are also regions connected by HSR that still suffer from industrial decline and high levels of unemployment (Nash, 1991;Vickerman, 1997).

As a result, it is not surprising that it has been difficult to verify empirically the impact of transport infrastructure on regional development. Banister and Berechman (2001) argued that there are three necessary conditions, viz., economic externalities, investment factors and political and institutional factors, essential for economic development to take place. Transport investment affects the location of

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economic activity, but not necessary its scale and efficiency, so that transport investment on its own is not a sufficient condition for regional economic development (e.g. Biehl, 1991; Keeble et al., 1982). Attempts to explain *changes* in economic indicators, i.e., economic growth and decline, by transport investment have been much less successful (Bröcker and Peschel, 1988).

Since the failure of Australia's last serious attempt at HSR in 2000, many changes have occurred that suggest that this form of transport should be re-examined. The newly elected Australian Government has announced initiatives to help drive economic prosperity in regional Australia and focus on major new investments such as transport infrastructure, broadband and health care (Gillard and Swan, 2010). Given the potentially high level of political support, HSR and regional development have the potential to be back firmly on the government's policy agenda. If a variety of services along East Coast inter-capital lines were considered, HSR could enhance accessibility between capital cities and regional centres, and thereby act as a catalyst for growth in these regional centres as part of a broader urban disaggregation strategy (CRC for Rail Innovation, 2010). This could result in a positive economic flow outward from capital cities such as Sydney and Melbourne, thereby creating powerful regional connections within the Australian economy. However, current capacity to measure the social-economic impact of HSR on regional economies in Australia remains underdeveloped. The need to recap the issues related to HSR and regional economic development in a more detailed analysis is therefore becoming increasingly urgent.

This paper investigates the degree to which international experience with HSR is appropriate to consider in the context of the assessment and development of an Australian HSR system, with particular attention paid to a) the socio-economic impacts of HSR on regional development, b) the means to quantify these impacts, and c) the development of a combined multiregional input-output (IO) framework in the Australian context based on the first two stages of this review.

2. Transport and Economic Development

2.1. What is a regional economic development impact?

The term 'economic development' is often not well understood. Many studies acknowledge the complexity of the concept and do not provide any simple definition (e.g., Blakely, 1994; Beer and Maude, 1997). While economic development is a broad field with different meanings to different people, it tends, in general, to enhance an area's level of economic activity across a number of areas:

- income – to improve the economic well-being of residents by increasing employment and raising personal income levels;
- job – to improve opportunities for job satisfaction and upward occupational mobility, by expanding the types of available jobs.
- quality of life – to expand local opportunities for shopping, social and entertainment activities in an area.
- stability – to improve the stability of jobs and income in an area through diversification to reduce reliance on declining industries (Haughton, 1999).

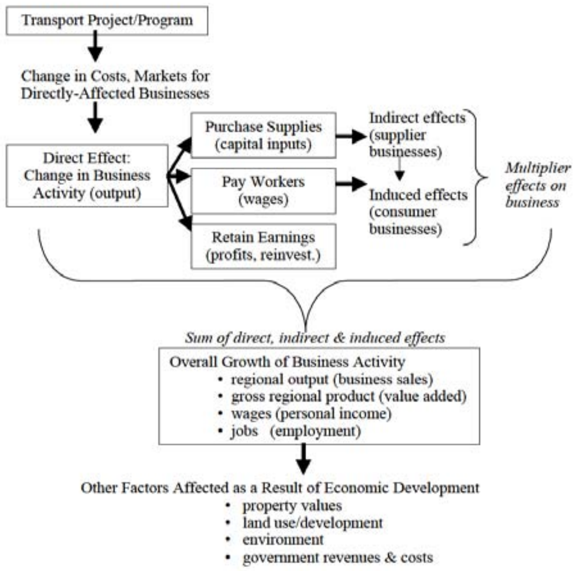
Hence, regional economic development impacts in this study are defined as impacts on the level of economic activity in a given regional area. These include changes in jobs, wages and business output resulting from monetary effects of transportation on income and costs for households and businesses.

2.2. How is an economic development impact measured?

There are many different ways of viewing and measuring economic development impacts of transportation projects. Impacts, in general, are typically measured in terms of change in a) output, b) gross regional product, c) personal income, and d) employment (McConnell and Bruce, 1999). Of course, there are many other indicators that focus on particular aspects of economic development impact, rather than overall expansion of an area's economy (De Rooy, 1995). These include measures of a) productivity, b) investment, c) property values, and d) taxes.

All these measures of impact can reflect the sum of *direct effects* on business growth (for businesses directly affected by changes in operating costs and markets), *indirect effects* on business growth (for suppliers to the directly affected businesses), *induced effects* on economic growth (for businesses affected by the re-spending of additional worker income), and *additional induced effects* on economic growth (from shifts in population, workforce, labour costs and prices). The sum of all these impacts represents the total effect on economic growth (Weisbrod, 2000). Figure 1 illustrates the functional interrelationships of these different impact measures. These direct, indirect and induced impacts measures will be used in this study.

Figure 1: Types of economic development impacts



Source: Weisbrod, 2000.

3. Literature Review

Development of new transport infrastructure influences both production and household consumption, which is assumed to lead to a reduction in transportation costs and travel times and may give rise to substantial redistribution effects among economic groups and also among regions (Rietveld, 1997). There exists a broad spectrum of theoretical approaches to analyse the impacts of transport infrastructure on regional socio-economic development. According to van den Bergh et al. (1996), several models have been designed to address the impact of transportation investment on spatial economies including:

- Production function models;
- Transportation network models;
- Multiregional input–output models;
- Multiregional computable general equilibrium models; and
- Integrated models

3.1. The established means to quantify the impacts of large transport infrastructure.

Production function models

In the production function approach, transport infrastructure plays a role next to traditional production factors such as labour and private capital. A general formulation of a production function for sector *i* in region *r*, with various types of infrastructure is:

$$Q_{ir} = f_{ir}\ (L_{ir},\ K_{ir};\ IA_r, \ldots,\ IN_r)$$

Where *Qir* is value added in sector *i* region *r, Lir* is employment in sector *i* region *r, Kir* is private capital *in* sector *i*, region *r, IAr, …, IN r* is infrastructure of various types in region *r*.

This method measures benefits by estimating rates of return on infrastructure investments in a production function approach, using cross section, time series, or panel data (Aschauer, 1989). The main problem associated with regional production functions is that econometric estimation tends to confound rather than clarify the complex causal relationships and substitution effects between production factors. As a result no clear conclusion has been reached (Oosterhaven and Knaap, 2003).

Accessibility and potential models

New transport infrastructure provision is assumed to lead to a reduction of travel time or cost. As a consequence, firm will be able to exploit changes in accessibility in increasing competitiveness, leading to increased regional output, increased per capital incomes and hence increased welfare (Vickerman et al 1997). Accessibility approaches attempt to measure the impact of transport cost reductions by accessibility indicators telling how a region's generalized cost of reaching its markets and travelling to a hypothetical set of destinations is affected by the associated cost reductions (Rietveld and Bruinsma, 1998). Accessibility changes are then related to regional economic indicators such as GDP growth by using cross-section regression techniques. In most cases, the economic potential concept was introduced to provide an approximation of the significance of changes in accessibility for the region's economy. This approach was shown to have a microeconomic foundation based on the profit-maximizing location behaviour of firms, but fail to capture these impacts at the macro level (Rietveld, 1998).

Gutierrez & Urbano (1996) examined the change in the accessibility from the development of the Trans-European network. The accessibility index was defined as a GDP weighted average of the arc and node impedances reflecting the quality of the road, minimum travel time, and population. They concluded that the Trans-European road network could reduce the initial disadvantages of the lagging regions in terms of accessibility. Vickerman et al. (1999) showed that the development of the Trans-European high-speed rail network could widen the differences in accessibility between central and peripheral regions. They specified the accessibility index with population and travel time between zones.

Regional input-output models

Input-output (IO) models have a long tradition in regional economics, starting with the work by Leontief and Strout (1963). The IO models are mostly used for studies that wish to incorporate structural economic relationships, i.e. inter-industry linkages by way of intermediate deliveries of goods and services. By calculating direct and indirect effects of exogenous variables (expenditures), one may obtain multipliers and effects on employment, and use of resources. One recent example of an operational multiregional IO model is the MEPLAN model developed in the United States. The disadvantages of the multiregional IO models are clear and depend mainly on their fixed character (Nijkamp and Padlinck, 1981): fixed input composition of output, fixed inter-industry interdependencies, constant returns to scale, and independence of prices and supply.

General equilibrium models

General equilibrium approaches involve establishing a multiregional computable general equilibrium (CGE) in which transport costs explicitly appear as firms' expenditures on transport and other kinds of business travel, and as the costs of private passenger travel incurred by households (Venables and Gasiorek, 1998). In Australia, the Monash Multi Regional Forecasting (MMRF) model has been used to analyse the regional impacts of a range of policies changes (see Peter et al., 1996). Recently, CGE models have often been used to analyse the causality of transportation infrastructure investment on economic growth, assuming that infrastructure capital is regarded as an unpaid and intermediate input on the supply side and as a construction investment demand on the demand side.

Integrated models

A growing number of integrated models which integrate spatial regional economic models with the transportation network have been implemented at the regional scale in recent years. This has been done in a wide variety of ways such as: extended multiregional IO models (Cho et al, 2000; Kim et al, 2002) and spatial CGE models (Kim and Kim, 2002; Bröcker and Schneider, 2002). In a broad sense, these models consist of the economic potential approach linked with the integrated transportation network model.

In order to address the issues relating to the link between multiregional IO model and the treatment of transport costs, many researchers use accessibility and potential concept as proxies for the relationship between the region and its input and output markets (Snickars, 1982). Cho et al. (2000) calibrated the economic impacts of industrial and transportation structure loss on the Los Angeles economy, using an integrated transportation network models, spatial allocation models, and input–output models. They estimated the full cost resulting from structural damage, business interruption, network performance, and infrastructure damage. Kim et al. (2002) developed an integrated transportation network and input–output model for estimating the regional and interregional commodity flows and transportation network flows for each sector.

Buckley (1992) analysed the impacts on spatial equity and efficiency using an interregional CGE model. The model specified economic activities of the transportation and the wholesaling service sector, and calibrated the costs of moving products based on origin-destination pairs. It showed that greater labour productivity in the transportation sector could decrease transportation costs both for the internal movement of locally produced tradable goods and for interregional exports. Seung & Kraybill (2001) investigated the effects of increased public investment on regional output and welfare in Ohio. Bro¨cker (2002) estimated the impacts of transportation costs and new road development of the Trans-European Transport-Networks (TEN-T) on the spatial distribution of the benefit in the European Community. His results indicated that the reduction in the transportation costs and the road development could lead to an improvement in income disparity in relative terms, but failed to generate a significant impact on enhancing a better income distribution in absolute terms.

One of the primary challenges for estimating transportation investment impacts using transportation network analysis is to practically integrate transportation activities with spatial and economic equilibrium approaches in a consolidated structure (van den Bergh et al. 1996). Our review of existing studies shows that all the reviewed approaches have their strengths and weakness. Although the CGE model succeeds in endogenously determining the prices and transport costs from inter-sectoral linkages, it often neglects both the quantitative and qualitative elements of the transportation investments in calculating the economic impacts (Kim et al, 2002). CGE models have been criticised for the use of restrictive functional forms and excessive reliance on calibration approaches in the parameterization of the models (Adkins et al, 2003). A combined model of accessibility approaches for transport cost reductions and multiregional IO for inter-regional/inter-industry linkages is therefore likely to have the potential to provide the best empirical answers to the question of determining the economic impacts of transport investment. The interactions between the transportation sector and the real side of the economy are measured in terms of monetary units as well as other dimensions, such as accessibility. While the limitations of the regional IO and accessibility approaches should be recognized, they are selected as the framework to be used in this study.

3.2. Determining the degree to which international experiences with HSR are instructive for the Australian context.

The Australian East Coast economy, including Queensland (QLD), New South Wales (NSW), Australian Capital Territory (ACT) and Victoria (VIC), is best known as an economy mainly producing financial services, together with manufactured and agricultural products. The magnitude of inter-state trade within the East Coast is often larger than believed. If an HSR link were developed between Sydney and Melbourne, it could directly affect a substantial portion of transportation network and production facilities in the East Coast and indirectly spread far beyond the region and thus affect other states and indeed the entire country. Thus, the analysis and estimation of inter-regional effects between East Coast states from using the transport links through the trade relationship are crucial to the evaluation of indirect/induced impacts from any proposed HSR project.

Suppose that one or more inter-regional transportation links are affected by a HSR project. How would the commodity/service flows and production process react? The answer to this question would seem to rely on a simple inter-regional commodity/service flow model with the regional consumption and investment by sector given exogenously. To develop such a model, it is necessary to combine models that are conventionally regarded as separate entities to take into account distance-based spatial interactions in regional IO models, (Kim et al., 2002).

Model development requires the integration of several regional IO models with a transportation accessibility model. An overview of the integration between transport network and regional economic models can be found in Fujita et al. (1999) and Baldwin et al. (2003). Pioneering examples of empirical potential studies for Europe is Keeble et al. (1982; 1988). In Japan, Yamaguchi et al. (1997) developed a regional IO model that examined the impact of a highway improvement project on Kanto regional economies, while Shibata and Kosaka (2009) developed an integrated transport network and nine-region IO model to analyse the effect of Japanese transportation system from 1965 to 2000. In Australia, the application of transport accessibility model and regional IO model has been fairly limited in comparison to those undertaken at the international level. In view of the approaches and their application discussed above, there is scope for advancing the application of developing an integrated transportation network and multiregional IO model to the analysis of potential HSR development in Australia.

We propose a new integrated approach including production, transport cost and accessibility. Within this approach, the commodity and service levels by sector react to changes in the transportation network, generating direct and indirect effects on both regional economic growth and interregional trade patterns in the long run (Shibata and Kosaka, 2009). We would be able to distinguish between the effects of HSR investment, including both changes in transport costs and therefore changes in accessibility, and models of regional and interregional structure.

4. Methodology

Outline below is a general framework of an integrated multiregional IO model that better address the needs of HSR and regional economic development policy analysis. The proposed model combines features currently found in various multiregional IO models reviewed above, with new features and approaches to accessibility index. The integrated IO model is a multiregional and multisectoral model, incorporating innovative features from recent developments in the literature like potential household income, as well as time costs of business transport as well as private passenger transport.

4.1. Overview

The integrated transport multiregional IO model consists of a transport model and a multiregional IO model. The transport model calibrates the accessibility of the HSR and air based on the minimum distances between different transportation zones, while the multiregional IO model estimates the economy-wide impacts of changes of the HSR and air accessibility on the spatial economies at a four-region division of Australia. The effect of the transportation infrastructure to economic sectors is transited through changes in the spatial accessibility level.

We concentrate on the comparison between HSR and air modes for two reasons. First, HSR has been seen as a dominating new mode on which much of the emphasis in Government development has been placed in dealing with transport issues between Sydney and Melbourne (BITE, 2010). It has been seen important because of HSR ability to save time and increase accessibility for connecting Sydney and Melbourne metropolitan areas. Second, HSR challenges air transport over distances of 400-800km where previously air has been dominant. It is therefore argued that HSR represents a paradigm for tackling Sydney and Melbourne transport issues.

In this paper, the following steps are involved in estimating the economic impacts of transport investments by closely following the theoretical framework developed by Shibata and Kosaka (2009).

(1) The calculation of an interregional minimum distance matrix by HSR and airports.
(2) The calculation of an accessibility index by HSR and airports.
(3) The injection of the resulting changes in the accessibility into the multiregional IO model.
(4) The calculation of the economic effects of the HSR and airports on GDP, exports, and the variation of the regional disparities for wages and employment.

4.2. Accessibility model

The transport model calculates the changes in the accessibility resulting from the HSR system development. The accessibility is an indicator of the level of services provided by a transport network, implying the ease of access between spatial opportunities. The determinants of the accessibility are minimum travel distances, time and costs between the origin and destination.

Establishment of a transportation accessibility evaluation index
A few representative nodes and links for each region will be set first, followed by the establishment of an evaluation index based on travel time and cost between these representative points by transport modes (e.g., HSR and air). More specifically, the interstate rail and air networks are constructed with different nodes and links, with these being defined as a) rail/air intersections and b) distance between representative locations. Representative locations in each region were selected based on the proposed HSR Southern route suggested by Infrastructure Partnership Australia (IPA, 2010). These representative locations are, Sydney, Canberra, Albury and Melbourne (see Figure 2).

Figure 2: An illustrative HSR route alignment between Sydney and Melbourne

Source: IPA 2010.

The evaluation criteria are a) required travel time to destination and b) charges incurred by using the transport network. In terms of b, the reduction in travel time is expressed in dollar value by introducing the concepts of time value and potential household income. For potential household income, the measurement method involves considering the opportunity cost of labour that could be saved owing to an early arrival at the intended destination. By multiplying the reduced travel time and hourly wage rate, we can compute the monetary value of potential household income occurring from travel time savings.

Accessibility evaluation index of HSR

$$T_{hsr}^{ab} = \frac{1}{wage\_m_{tm} / wage\_m_{to}\left(hsr\_tim_{tm} + hsr\_cost_{tm}\right)} \Bigg/ \frac{1}{wage\_m_{to} / wage\_m_{to}\left(country\_tim_{to} + country\_cost_{to}\right)} \quad (1)$$

T_{hsr}^{ab} : accessibility evaluation index for movement by HSR from the region *a* to region *b*.
$country\_time_{to}$: time value in the base year when using the conventional rail lines.
$country\_cost_{to}$: real cost in the base year when using the conventional rail lines.
hsr_time_{tm} : time value in the comparison year when using the HSR line.
hsr_cost_{tm} : real cost in the comparison year when using the HSR line.
$wage\_m$: mean nominal monthly wage.
$\frac{wage\_m_{tm}}{wage\_m_{to}}$: nominal wage comparison between base year and comparison year.

Table 1: Rail service between representative locations

Distance	Original route	New route
Sydney ⇔ Canberra	Country link	HSR link
Canberra ⇔ Albury	Country link	HSR link
Albury ⇔ Melbourne	Country link	HSR link

Accessibility evaluation index of Air

The accessibility evaluation index of air is developed in the same way.

$$T_{air}^{ab} = \frac{1}{wage\_m_{tm} / wage\_m_{to}\left(air\_tim_{tm} + air\_cost_{tm}\right)} \Bigg/ \frac{1}{wage\_m_{to} / wage\_m_{to}\left(air\_tim_{to} + air\_cost_{to}\right)} \quad (2)$$

T_{air}^{ab} : accessibility evaluation index for movement by air from the region *a* to region *b*.
air_time_{to} : time value in the base year when using air.

air_cost_{to} : real cost in the base year when using air.
air_time_{tm} : time value in the comparison year when using air.
air_cost_{tm} : real cost in the comparison year when using air.
$wage\_m$: mean nominal monthly wage.
$\frac{wage\_m_{tm}}{wage\_m_{to}}$: nominal salary comparison between base year and comparison year.

Table 2: Air service between representative locations

Departure	Airport
Sydney	Charles Kingsford Smith
Canberra	Canberra International Airport
Albury	Albury Airport
Melbourne	Tullamarine

Accessibility evaluation index with consideration of substitution effect

In reality, substitution effects occur between different transportation modes. For example, if demand were concentrated in HSR, users would consequently shift from other transport modes such as air to HSR. In particular, the air link between Melbourne is rated as the fourth busiest in the world (CRC for Rail Innovation, 2010), with HSR expected to compete effectively with air travel on this route. As a result of these considerations, the substitution effect between these two modes is expressed in following equations.

$$TT_{hsr}^{ab} = \left(\frac{T_{hsr}^{ab} T_{hsr}^{ab}}{T_{hsr}^{ab} T_{air}^{ab}}\right)^{\frac{1}{2}} \quad (3)$$

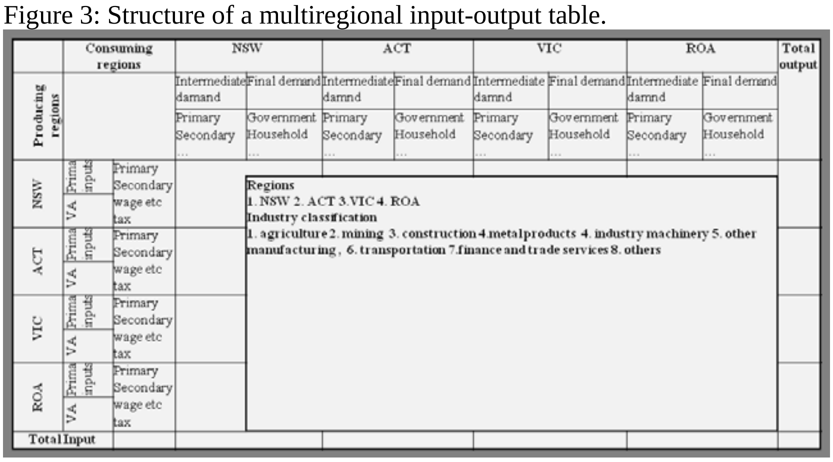
$$TT_{air}^{ab} = \left(\frac{T_{air}^{ab} T_{air}^{ab}}{T_{hsr}^{ab} T_{air}^{ab}}\right)^{\frac{1}{2}} \quad (4)$$

4.3. Multiregional IO model

Construction of an a multiregional input-output table

This model will divide the Australian economy into 4 regions, namely NSW, ACT, VIC and Rest of Australia (ROA) based on the Monash-MRF (see Figure 3). In each region, production activities are divided into eight industrial sectors: agriculture, mining, construction, metal products, industry machinery, other manufacturing, transportation, finance and trade services and others. Each industry is assumed to produce a single representative good under constant returns to scale and perfect competition in the commodity and labour markets.

Figure 3: Structure of a multiregional input-output table.



The multiregional IO model

The multiregional IO model estimates the effect of the HSR on economic growth and the changes in regional disparities in Australia. The multiregional IO model contains six different blocks of modules, these being:

Potential household consumption

In this model, household consumption is treated as an endogenous variable in the final demand block. The change in household consumption is calculated based on changes in ‘potential household income”.

$$log(CPR_i^{ab}) = \alpha_i + \beta_i\, log(\frac{WAGE^b}{P_c}) + \beta_i^{hsr}\, log(\frac{T_{hsr}^{ab} WAGE^a}{P_c}) + \beta_i^{air}\, log(\frac{T_{air}^{ab} WAGE^a}{P_c}) + \gamma_i\, log(\frac{P_i}{P_c}) \qquad (5)$$

Where CPR_i^{ab} is the household consumption of region *b* for commodity from industry *i* of region *a.* $WAGE^a$ $WAGE^b$ are the wage of region *a* and *b*. p_i is the price of the commodity from industry *i*, p_c is the macro consumer price index. T_{hsr}^{ab} T_{air}^{ab} are the accessibility index of HSR and air. This equation indicates that the private consumption of region *b* is affected by accessibility index and wage of neighbouring region *a,* which could be defined as ‘potential household consumption’.

Employment

$$L_j^b = \beta(XXR_j^b)^{\beta}(T(N)_{hsr}^b)^{\delta_{hsr}^b}(T(N)_{air}^b)^{\delta_{air}^b} \qquad (6)$$

Where L_j^b is the total employment in industry *j* of region *b*. XXR_j^b is the total production of industry *j* in region *b*. $T(N)_{hsr}^b$ and $T(N)_{air}^b$ are the accessibility indices of HSR and air for neighbouring regions of region *b*. The employment in industry *j* of region *b* can be explained by the improved accessibility to region *b* from neighbouring regions. Table 3 specifies the definition of neighbouring regions.

Table 3: Definition of neighbouring regions

Base	Neighbouring regions	
	HSR	Air
NSW	ACT, VIC, QLD	ACT, VIC, ROA
VIC	ACT, NSW	NSW, ACT, ROA
ACT	VIC, NSW	NSW ,VIC, ROA

Note: ROA means rest of Australia.

Intermediate input transaction coefficient

$$mxr_i^{ab} = \beta_i^b(T_{high}^{ab})^{\beta_{i,high}^{ab}} \qquad (7)$$

Where m_i^{ab} is the intermediate input transaction coefficient (the import share of commodity *i* purchased by region b from region *a*). T_{high}^{ab} is the accessibility index of highway between region *a* and *b*. Since road transport plays a dominant role in transporting commodities between Sydney and Melbourne, it is used as the main explanatory variable here. The explanatory variable HSR is not included in the equation because HSR is used for transporting passenger not commodities.

Total production

The total production in industry *i* of region *a* of the four regional input-output tables is determined as follows:

$$\sum_{b=1}^{r}\sum_{j=1}^{n} mxr_i^{ab}\, axr_{ij}\, XXR_j^b + F_i^a = XXR_i^a \qquad (8)$$

Where axr_{ij}^b is the intermediate input coefficient. F_{ij}^a is the final demand for commodity in industry *i* from region *a.*

Industry price

Industry price is determined by the cost structure of production factors such as raw materials and labour. This indicates the vertical structure of the IO table. In this study, $WAGE_j^b$ is treated endogenously.

$$P_j = \alpha_j + \beta_j \left(\frac{\sum_b WAGE_j^b}{\sum_b XXR_j^b}\right) + \gamma_j \left(\frac{\sum_b \sum_i \sum_a xvr_{ij}^{ab}}{\sum_b XXR_j^b}\right) \quad (9)$$

Where xvr_{ij}^{ab} is the intermediate input purchased by industry *j* of region *b* from industry *i* of region *a.*

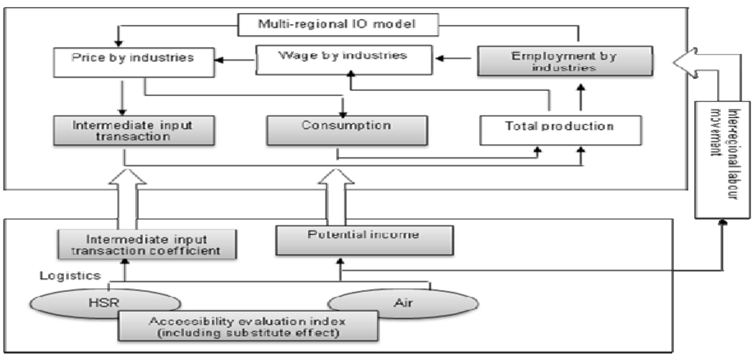
Wage rate

$$Wage\_rate_j^b = \beta_j^b \left(\frac{XXR_j^b}{L_j^b}\right)^{\beta_j^b} \quad (10)$$

Where $Wage\_rate_j^b$ is the per capita wage rate in industry *j* of region *b*. Wage rate is considered as the output per capita by regions and by industries. In other word, it is assumed to be described as labour productivity.

Figure 4 provides an overview of the methodological framework from the perspective of HSR policies. In this figure, changes in transport costs trickle down through the economy, thereby affecting regional (as well as national) economic development. Changes in transportation infrastructure directly affect the potential household income and business logistical costs that indirectly influence the intermediate demand, consumption and regional production process. Changes in transportation infrastructure also affect labour markets via commuting and the possibility of interstate migration. These changes in regional production, potential household income, dispersion and agglomeration, and employment could be captured through the direct, indirect and induced effect measures previously discussed in a multiregional IO framework.

Figure 4: The effect of infrastructure changes in the model



Source: Adapted from Shibata and Kosaka, 2009.

4.4. Data requirements and application

In general, there are three types of socio-economic data required by the combined IO model. These are a) regional commodity flow data, b) wage data, and c) transport cost data. The model's database will primarily be based on the multi-regional IO database of Australia for 1996 estimated and constructed by Monash University. This database divides Australia into six states and two territories. The Monash 1996 table will be used as the base-year table. However, it is not possible to state clearly how the inter-regional impacts have transformed in the comparison year since a new comparison year table after 1996 is not available. The development of the comparison year multiregional IO database will be a significant challenge for this study. Data on wages (including earnings and on-costs) by industries and regions is available from industry salary surveys, the Australian Bureau of Statistics' (ABS) *Average Weekly Earnings Australia*, or from consultation with business. The data for the rail and air network will be based on data held by the federal and state transport departments.

Transport infrastructure and socio-economic scenarios can be simulated each separately or in any of reasonable combination. The first scenario consists of assumptions about the development of the Australian HSR network. These assumptions have the form of backcasts of the HSR and air networks representing their evolution as well as forecasts of their development in the future, including

- Do-nothing Scenario: no network changes are implemented;
- HSR Scenario: only HSR links are implemented;
- Air Scenario: only air links are implemented; and
- All Scenario: all air and HSR links are implemented.

In addition to the transport scenarios, the socio-economic macro trends assumed for the transport infrastructure scenario can also be estimated. The main indicators for the regional consequences are impacts on total national production, regional household income (Gini coefficient), regional dispersion and agglomeration effects and regional employment.

5. Conclusions

This paper has provided an overview of the issues and the modelling approaches found in the literature so as to estimate the economic impacts of transport infrastructure investments on regional development. Particular attention has been given to the issues arising from multiregional linkages and spatial effects at the sub-national scale. From this overview, it can be concluded that a combined model of transportation accessibility and multiregional IO is most suitable for modelling the inter-industry/inter-regional impacts of new transport infrastructure at the regional level. This study therefore sets up a methodological framework for the assessment of the spatial economic impacts of any potential HSR project by describing the extension and refinement of the already existing IO regional economic models in the Australian context. Furthermore, the study defines the system of regions, establishes a sectoral categorization, and provides an overview about the model's requirements to the common data basis.

The structure of the enhanced multiregional IO models has the potential to enable the indirect spatial economic impacts to be analysed in several ways. First, the impact on the different industrial and service sectors can be identified, both within and across the states. Second, the change in employment and economic activity for each region will enable the distribution of indirect impacts and changes in growth prospects across the different regions to be determined. Third, estimated welfare effects by regions will provide information for the socio-economic distribution analysis for the public debate of developing an Australian HSR system. However, this combined IO model's data requirements are enormous. Some of the required statistical information is simply not available from the existing database.

While it is clearly not practical to engage in sophisticated modelling for all the elements of economic impact associated with HSR 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 in the field of regional economic assessment, further research on this matter is clearly warranted.

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