Estimating Regional Freight Movement in Australia Using Freight info Commodity Flows and Input-Output Coefficients

Jian Wang*

Southern Cross University, Australia

Topics
17 Transportation Input-Output Modelling

Abstract

Understanding why and where freight moves is critical for transport infrastructure investment and land use planning, and ultimately for the development of logistic policies that boost the economic performance of regional Australia. However, estimating and projecting regional freight movements by transport modes in Australia is a largely unsolved issue. Traditional statistical projection based on observed freight movements fail because they do not establish relationships between the generation of traffic and possible explanatory variables.

Freight is a derived demand. It moves to satisfy demand (consumption by households and business) from points of supply (production). Consequently, estimates of freight movement should not merely focus on the movement event, but should take into account the underlying economic drivers behind household/industrial consumption and industrial production. This paper first provides an overview of the basic issue, the contributions of empirical literature and the modelling approaches used until now. A commodity-based framework utilising commodity flow surveys and input-output coefficients is then proposed to illustrate how that might be applied in an Australian context. The proposed commodity-based framework has the potential to capture the fundamental economic mechanisms that drive freight movement and can be easily adapted to multimodal analysis in conjunction with other sub-models for the mode choice process.

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* Postdoctoral Fellow, Southern Cross Business School, Southern Cross University, Australia, email: jian.wang@scu.edu.au

1. Introduction

The East Coast boasts Australia's largest capital cities, major manufacturing centres, the largest ports and the greatest population. According to projections prepared by BTRE and for the North–South Rail Corridor Study, the tonnage of freight moving between Melbourne and Brisbane is expected to approximately double over the next 20 years(BTRE 2003 and 2006). Freight outside the 'bulk business' such iron ore and coal, including the agri-businesses, semi-processed and manufactured goods, are mostly moved by road (RTSA 2012). Increased truck traffic is associated with added highway congestion, more delay due to accidents, and accelerated highway deterioration. In addition, rapid changes in economic linkages are leading to ever changing flow patterns and the spatial restructuring of metropolitan areas. As freight flows and their impacts increase, transportation planners and operators have a greater interest in developing better methods for tracking and analysing commodity flows. This could provide much needed information for decision maker to better understand the types, values and economic importance of non-bulk freight movement to, from and within the East Coast corridors and the issues for contestability between rail and road.

For various reasons, it has been suggested that forecasting freight transportation flows is more complex than modeling passenger travel volumes (Horowitz and Farmer 2000). This is partly because of the numerous parties involved in shipping the large variety of commodities that are regularly moved by the several modes available. The development of freight forecasting techniques, therefore, has historically lagged behind the development of passenger techniques. In general, the demand generation models examine the productions and attractions of fright movements that begin or end in a geographic zone based on the characteristics of that zone (TRB 2008). The demand generation models used in the context of freight transport can be classified into three main types: trend models, zonal trip rate models and input output (IO) and related models. Many trend line analysis estimating and forecasting freight flow relies on traffic counts and the base year data to estimate future traffic growth factors (Huang 1998). Since freight demand is a derived demand, it is better explained when derived from economic activities rathe than from traffic counts and projections. Moreover, traffic counts show little relationship between the growth of freight traffic and possible explanatory variables. To forecast freight flows, other researchers use a set of annual or daily trip generation rates to provide annual flows originating or terminating in geographic zones, these models, however, require costly Origin-Destination (OD) survey data for calibration (Sorreatini and Smith 2000). To conclude, current research in freight relies on a limited source of data for truck and train forecasting, based on mainly either expensive or time consuming traffic surveys or inefficient truck traffic counts. A better way to derive freight flows is to use reliable secondary data on the region's industrial structure (Liu and Vilain 2002). As these data are often readily and cheaply available (e.g. National and regional IO tables), it is a both practical and reliable tool for forecasting freight flows. Moreover, there does not appear to be any substantial Australian work on estimating commodity flows using IO data. An examination of current commodity flows to a region using a commodity-by-industry IO model in Australia could bridge this gap.

The remainder of this paper is organized as follows. The second section describes the term "freight" and review current freight flow methods and their problems. The third section presents the conceptual framework for our model. The last section presents discussions and some concluding remarks for the potential application of the proposed framework.

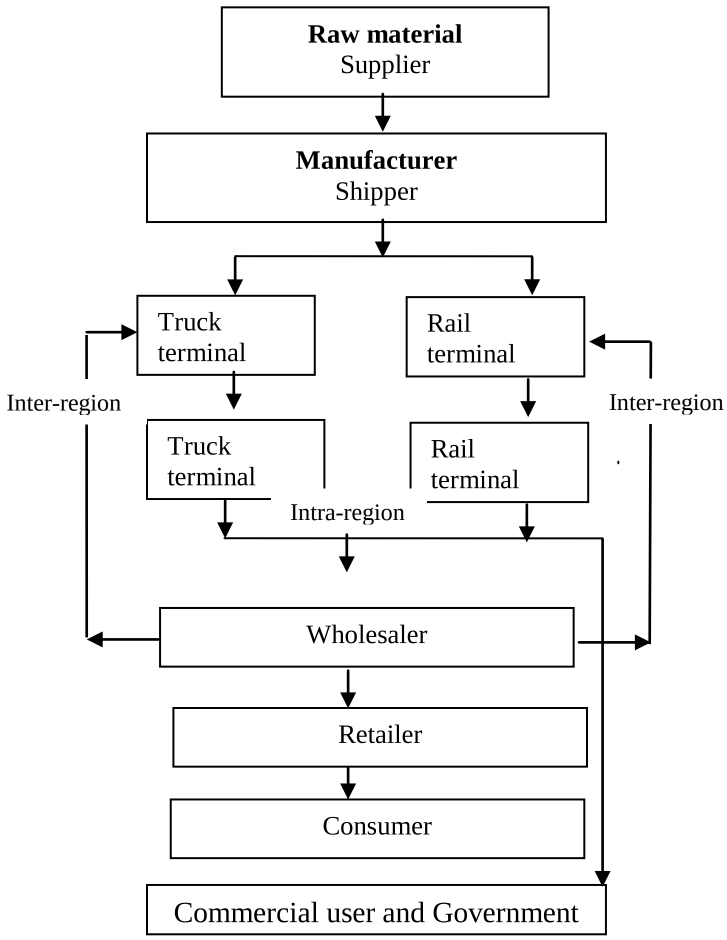
2. Freight policy issues and current modelling practice

2.1. "Freight" defined

According to Luk and Chen 1997, freight is an essential part of economic activities and arises from the demand for goods. The demand for freight is a derived demand because freight transport demand does not arise from the transport system, but from the demand for goods. The U.S Transport Research Board (TRB) shared the same view and argued that "freight" in its most basic sense, refers to goods transported from an origin to a destination and freight movement is not an end in itself, but serves an economic purpose to ensure that products reach a location where they can be consumed (TRB 2008). For this reason, demand for freight stems from the economic requirement to move goods from a production site to a market. The “production-consumption” definition is now seen as essential for making forecasts of change in freight activity, since it is the only way to predict growth at the two ends of the movement (Elaurant, Ashley and Bates 2007).

Freight demand arises from the process of production, distribution and consumption. The locations of the production and consumption influence where and how a good is moved. Figure 1 illustrates the “transport chain” showing various components in that chain (Flagstuff consulting 2000).

Figure 1: Freight movement process.



Source: author’s revision based on Flagstuff Consulting 2000.

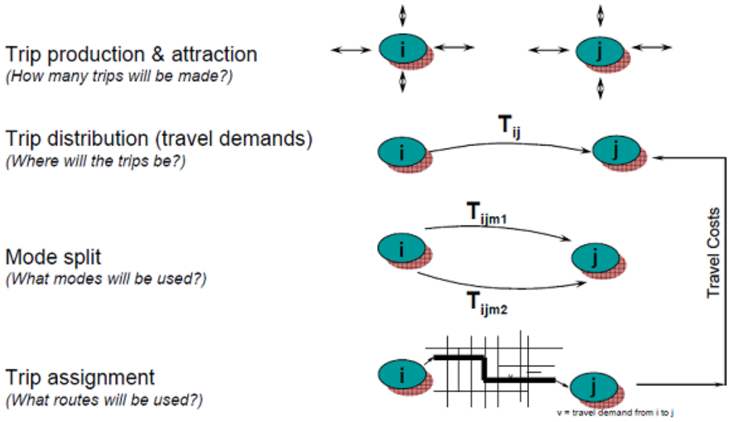
2.2. Current modelling practice

Many modelling concepts applied in freight transport forecasting have originally been developed for passenger transport. There is an general consensus among most researchers that the four-step transport modelling structure from passenger transport can be applied to freight transport as well (e.g. Pendyala, Shankar and McCullough 2001 and de jong, Gunn and Walter 2004). The four steps in the context of a freight transport model system are (Figure 2):

- Trip production and attraction. This step determines the quantities of goods to be transported from the various origin zones and the quantities to be transported to the various destinating zones. The dimension could be monetary units.

- Trip distribution. This step determines the flows in goods transport between origin and destinations. The dimension is tonnes. Flows are converted to trips once they are allocated to origins and destinations based on commodity specific payload data.
- Modal split. This step determines the location of the commodity flows to modes (e.g. truck, train, intermodal, waterways). Once commodity flows are assigned to origins and destinations, they are converted to trips by mode.
- Trip assignment. After converting the flows in tonnes to vehicle-units, they can be assigned to specific highway and rail networks.

Figure 2: The Four Step Commodity Model



Source: DOT 2009.

In this remainder of this section, we review the contributions of empirical literature and the modelling approaches developed for the production and attraction step. de Jong, Gunn and Waler (2004) distinguished three types of models for freight generation that have been applied in practice from the concept of production and consumption:

- Trend and time series models
- Zonal trip rate modes; and
- Input output and related models.

In trend models, historical trends are extrapolated into the future. The method produces future estimates of flow on a facility based on applying growth factors to the flow on that facility. To forecast future freight demand specific to a particular facility, time series regressions can be constructed to extrapolate future growth rates, or forecasts can be performed on specific economic variables that influence freight demand (Alstadt and Coughlin 2012). Some examples are the Minesota Trunk Highway 10 Truck Trip Forecasting Model and the Heavy Truck Freight Model for Florida Ports (FHA 1999). Trend and time series analysis is particularly appropriate when forecast is short term and insufficient time and resource exist to build and calibrate a behavioural model. The most desirable indicator variables are those that measure goods output or demand in physical units (tons, cubic feet etc). However, forecasts of such variables frequently are not available. This method is relatively simple and is used to rapidly apply existing data to determine one or several forecast volumes (TRB 2008). Usually, the method is intended for short-term forecasts, many assumptions are needed to make if work effectively and its range of applicability is limited (TRB 2008).

Zonal trip rates for production and attraction are usually derived from classifying cross-sectional data on transport volumes to/from each zone in the area under investigation (or another similar area) into a number of homogeneous zone types. Examples of such rates can be found in the Quick Response Freight Forecasting Manual (Cambridge Systematics 1997) and in the Guidebook on Statewide Travel Forecasting (FHWA 1999). This method is easy to implement. However, the default parameters like truck trip generation rates are not easily transferable between different regions (Giuliano et al 2010).

Input output (IO) models attempt to quantify the inter-dependent relationships of various economic activities within an economic region. There is a long standing tradition that links the analysis of intersectorial economic flows with the analysis of the associated commodity flows. In recent years, an increasing number of applications have tried to use the modelling framework for freight transportation modelling (e.g. Jack Faucett and Associates 1999, Sorratini and Smith 2000, and Giuliano et al 2010). In practice most of the models reviewed adopt a hybrid approach to determining freight flows. For the most part of these applications, an IO table is used to estimate the total amounts of commodities being attracted by a given zone as a function of the anticipated level of economic activity. While a multi-regional input-output (MRIO) models the entire set of economic and commodity flows, the above approach use the IO as a commodity attraction model. Such approaches represent a hybrid between the formal MRIO models and the traditional transportation models. Unlike the MRIO approach which consider transportation as one of the economic sectors, hybrid approach use the IO table to estimate the attractions for sectors different from transportation is more robust to changes in transportation accessibility (Holguin-veras et al 2001). One of the limitations of this approach is that it requires a set of IO technical coefficients for each and every one of the transportation analysis zones (which are likely to be difference). For example, in one region the number of employees might have a strong relationship with the amount of freight produced in the chemical sector but the relationship is different in another region. Nevertheless, IO approaches assists in the identification and application of periodically published economic datasets in a framework that allows refinement as knowledge improves (SdD 2004).

Examples of multi-regional IO models in freight transport are:

- The Italian national model system for passengers and freight (Cascetta1997) which uses 17 sectors and 20 regions.
- The REGARD model for Norway, with 28 sectors which produces demand used in the Norwegian freight model NEMO (see EXPEDITE, 2000)
- The model for Belgium developed by ADE with 17 sectors which produces demand used in the Walloon Region freight model WFTM (Geeerts and Jourquin, 2000)
- The Dutch model TEM-II (see Tavasszy, 1994) and the present Swedish model system SAMGODs use a multi-sectoral national IO table.

Computable general equilibrium (CGE) models established equilibrium in several related markets. Spatial CGE models (e.g Brocker 1998) have been developed recently that might become operational models for international and regional forecasting and evaluation, but there is still a long way to go (Tavasszy et al., 2002).

Table 1: Summary of freight demand generation models

Models	Pros	Cons
Trend time series models	Limited data requirements	Limited insight into causality and scope for policy effects.
Trips rates	Limited data requirements (zonal data)	Limited insight into causality and scope for policy effects.
IO	Link to the economy can give land use interactions. Policy effects if elastic coefficients.	Need MRIO tables. Restrictive assumptions if fixed coefficients; need conversion from values to tonnes.
CGE	Limited data requirements; transport and land use interactions.	No statistical test on parameter values

Source: Author’s revision based on de Jong et al. 2004.

2.3. Data problems and research gap

Despite the attention paid to the modelling of freight demand generation and advances in modelling methods, the development of practical and reliable tools for forecasting freight demand have been limited (Elaurant et al 2007). This limitation has been due to the lack of freight transportation data. Freight data has been traditionally difficult to collect due to the proprietary nature of the data and due to the difficulty with identifying the proper entity to which a freight transportation survey needs to be administrated (Jonnavithula 2004). It would be ideal to have up-to-date and reasonably detailed freight movement data on commodity flows by industry sector, mode, origin and destination at a geographic scale sufficiently fine to identify to flows on specific routes or at specific locations (Giuliano et al 2010). Collection of such reliable and comprehensive freight data has traditionally relied on large sample survey methods. Survey based collections, however, are very expensive, especially for origin destination level survey data, and there are usually considerable time lags between activity, data collection and data availability (Mitchell 2010).

In Australia, detailed OD freight surveys have been undertaken very infrequently. The last 'comprehensive" survey of OD freight movements was the Australian Bureau of Statistics 2000-01 Freight Movement Survey (FMS) (Mitchell 2010). Accurate, up-to-date and reasonably detailed freight movements data is crucial for informed policy analysis, freight transport modelling and infrastructure investment evaluation. However, the breadth and diversity of freight industry activity means detailed freight data is typically very costly to collect. Consequently, comprehensive freight data collections have been infrequent and restricted in scope to limit costs. Reliable secondary sources such as regional IO tables, state-level commodity flow data and employment data can provide a cost effective way to estimate freight flow while maintaining an acceptable level of accuracy (Liu and Vilain 2002). To the development of the IO based freight generation models, Hybrid models only need IO technical coefficients for estimation of commodity attraction and the matrix of interregional trade flow coefficients is not required. To forecast, in general, hybrid models will need an estimation of the technical coefficient matrix, estimates of the economic activity and commodity production at each zone.

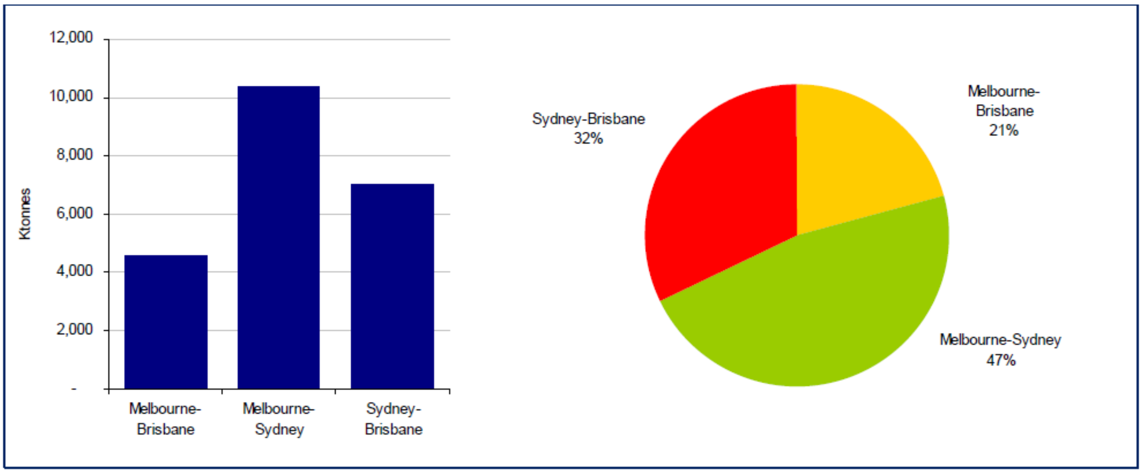
Giuliano et al 2010 developed a robust and practical statewide modelling framework that can be used to estimate freight generation demand using data contained in readily available databases. In view of the Guiliano et al 2010 approach and its application, there is scope for advancing such application to the estimation of regional freight movement in Australia. Thus, the objectively of the study, is to propose a relative data simple, but behavirally robust statewide freight generation modelling framework in the Australian circumstances.

3. Proposed Framework

3.1. The proposed model framework

According to Ernst & Young 2006 and ARTC 2007, the East Coast corridor service three distinct interstate non-bulk (general) freight markets. The total road and rail freight movements within the corridor between the state capitals account for 22 million tonnes (10% of the total freight flow). Of the inter-capital city freight an estimated 47% is on the Melbourne-Sydney corridor, 32% is on the Sydney-Brisbane corridor and 21% on the Melbourne-Brisbane corridor (Figure 3). Rail is most competitive on the Melbourne and Brisbane corridor with an estimated 30% of market share. On the other two corridors market shares are estimated to be 9% between Melbourne and Sydney, and around 11% between Sydney and Brisbane.

Figure 3: Inter-capital freight



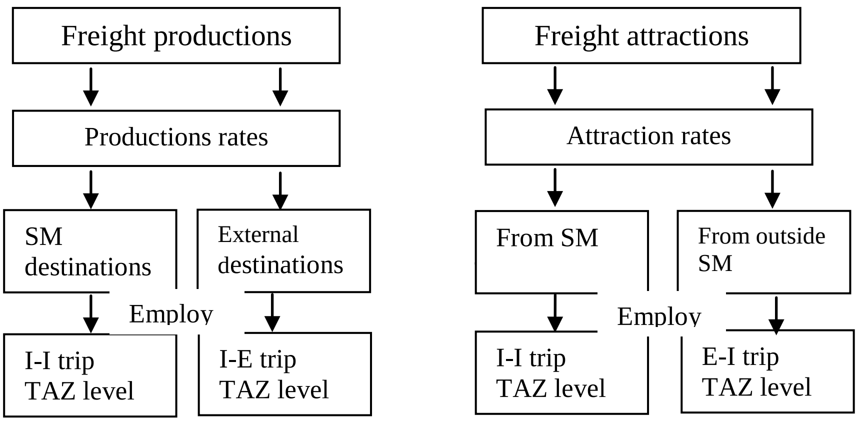
Source: Ernst&Young 2006

The proposed study will utilise the best available public database to develop a commodity-based framework utilising commodity flow surveys and input-output coefficients, and hence identify issues affecting contestability between rail and road on the Sydney-Melbourne corridor. Giuliano et al 2010 used widely available (non-proprietary) and frequently updated data to estimate link-specific freight flows on trucks for the highway network of in the Los Angeles five-county area. In this study, the following steps are involved in estimating the production and attraction of freight on the Sydney-Melbourne corridor by closely following the theoretical framework developed by Giuliano et al 2010. This work builds on their approach. The major research steps involved are the following:

1. Estimate commodity-specific interregional and international trip attractions and trip productions for those locations where airports, ports, rail yards or regional highway entry-exit points are located.
2. Utilize a regional input-output transactions table to estimate *intraregional* commodity-specific trip attractions and trip productions, and allocate these to small-area units.
3. Create a regional commodity origin-destination matrix using estimates from (1) and (2).

Figure 4 below gives an overview of the proposed model structure. Freight production can be inferred from various measures of economic activity, such as monetary measures and employment data by economic sector. Monetary values are converted to physical units tons provided that an average value per ton of each commodity is known. Employment data from the census are used to convert state production in tons by sector at the state level and later to Traffic Analysis Zone (TAZ) level in tons. Freight attraction is considered to be final demand being the consumption of commodities by households and businesses and may include distributor and retail centers. Determining attraction freight flows can be more problematic than estimating generated freight flows due to their more complex channel structure. This study uses the IO coefficients to derive the industrial and consumption attractions.

Figure 4: Proposed model structure



Note: II (Interal-Internal); IE(Internal- External); EI(External-Internal)
Source: Author's revision based on Sorratini 2000.

For interregional flows, a series of data source to generate trip attractions and productions for the major import/export nodes is used. A regional input output model and small area employment data are the basis for generating intraregional trip attractions and productions. Commodity attractions and productions are combined into an origin destination matrix. These flows are then converted from dollars to tons to vehicles and then assign to the transport networks using transportation model.

3.3. Model Data Sources

In order to estimate total freight shipments on the highway and rail networks between Sydney and Melbourne, we must account for shipments (in tonnage) to and from all sources, both within the region and to and from the region. We need IO data for commodity information and to inform the distribution of freight supply and demand within the region. We also require information on shipments by mode in order to generate a truck and train shipment O-D matrix. These requirements determine our selection of data sources. In this section we describe the main data sources available in Australia.

Inter-regional Commodity Flows

The first research step requires data on inter-regional commodity flows through airports, ports, rail yards or regional highway entry-exit points. Several data sources are required to estimate the required flows.

Commodity Flow Survey

The Commodity Flow Survey (CFS) has been done in Australia infrequently. Freightinfo is a privately owned data base carried out by the firm FDF Management Pty Ltd. It is a commodity flow survey containing detailed information about the movement of commodities between zones called Statistical Divisions (SD). This survey collects inputs and outputs from commodity producers, as well as transport modes, origin-destination, and some pipeline and conveyor movements.

The methodology used in this survey involves the disaggregation of the commodity database produced by the Australian Bureau of Statistics (ABS). The disaggregation is adjusted for imports and exports using external data sources. Modal split is also inferred using external data sources (from rail, ports and airline operators). The data sources combination becomes the main limitation of this database, as its statistical error depends strongly on the range and diversity of data sources involved. Another problem is the accuracy of the road freight movement, which is estimated as the remaining freight after accounting for all the movements made by the other transport modes. While acknowledging the limitations of Freightinfo, it is used as the main data source in this study.

TERM

The Monash TERM (The Enormous Regional Model) has identified a full 144-sector, 57-region database. It provides a strategy for creating a "bottom-up" multiregional database which treats each region of a single country as a separate economy. TERM also includes SD-level inbound/outbound flows, as well as state and national-level foreign imports and exports information.

ABS

The Australian Bureau of Statistics and the Department of Transport and Infrastructure provide quarterly exports and imports by customs district by detailed Harmonized System (HS) commodity codes or annual exports and imports by port by Standard International Trade Classification (SITC).

Other sources

Freight Movement Survey (FMS) is carried out quarterly by the Australian Bureau of Statistics since June 1994 (unfortunately this survey has been suspended from 2001). This survey collects freight movements by commodity group, mode (including road, rail, sea, and air), weight, and origin-destination. The sample consists of all the non-road carriers and about 5,000 road freight carriers (including all road freight carriers operating more than 20 vehicles). One caveat is that overcounting may easily occur, as the units of measure are individual movements and hence loads transported with more than one operator may be counted more than once. Another potential problem is the exclusion of light commercial vehicles (less than 3,5 tonnes) and short movements (less than 25 km).

Intra-regional Commodity Flows

Data sources for intraregional commodity flows are straightforward: a regional input-output (I-O) transactions table and small area employment data. The I-O table will be developed from the TERM economic impact modeling system and provides up-to-date inter-industrial transactions by industry sector. Inter-industrial transactions are described in dollars. Small area employment data can be derived from state employment development department records. Yearly jobs are classified in Standard Industrial Classification code. Small area employment data is the basis for converting inter-industrial transactions to inter-zonal commodity flows. However, no reliable employment data is available at the TAZ level. As a second best solution, population could be used for disaggregation.

3.4. Estimations

Interregional commodity flows

We divide Australia into three regions (in this case the greater Sydney-Melbourne area, hereafter referred to as SM), the rest of the Australia (hereafter referred to as AU) and the rest of the world (hereafter referred to as ROW). We use the TERM data to derive each of these flows by industry sector. TERM does not provide all 3 flows directly. For this research, we aggregate the TERM information to 9 commodity sectors that match those of the Freigtinfo data available for the SM area. Once the flows have been estimated for each of the nine commodity sectors, we use the Freigtinfo data to allocate flow proportions to two modes: rail and truck.

Intraregional flows

For the estimation of intraregional freight trip ends, two expressions from Giuliano et al 2010 are used to estimate attractions and productions of commodities at each TAZ. The approach requires a regional input-output transactions table and small area employment data (introduced in Cho et al., 1999). The regional input-output model provides the basis for estimating zone-to-zone shipments, once the regional coefficients are combined with small-area employment-by sector data.

Specifically, equation (1) calculates the total commodity i required to support production in zone z:

$$D_i^z = \sum_j a_{ij} X_j^z \tag{1}$$

where, X_j^z is the total regional output of commodity *j* in zone *z*, given base year employment in sector *j* and zone *z*, a_{ij} is the *i*, *j*th element of **A**, the matrix of value demand coefficients for the (open) input-output model; this represents the flow from *i* to *j* per unit output of *j*, D_j^z is the total flow attracted from sector *i* in response to the demand in zone *z*, expressed in dollars. D_j^z represents the shipments of commodity *i* to zone *z* from all other zones to accommodate local demand, excluding household final demand and non-local final demand (imports).

Similarly, Equation (2) calculates the total supply of output *j* furnished by zone *z*,

$$O_j^z = \sum_i b_{ij} X_{ij} \tag{2}$$

where, X_j^z is the total regional output of commodity *i* in zone *z*, given base year employment in sector *i* and zone *z*, b_{ij} is the *i*, *j*th element of **B**, the matrix of value supply coefficients for the (input-output model. This is the flow from *i* to *j* per unit output of *i*. O_j^z is the total flow produced from zone *z* to satisfy the demands by sector *j*, in dollars.

O_j^z represents the shipments of commodity *j* to all other zones to accommodate local demand,, again excluding household and non-local final demand (exports).

The total output of commodity *j* in zone *z* is calculated as zone *z*'s proportion of all employment associated with commodity j:

$$X_j^z = \frac{E_j^z}{\sum_z E_j^z} \left(\sum_i x_{ij} + \alpha H_j + R_j \right) \tag{3}$$

where E_j^z is the employment by sector *j* at zone *z*, H_j is the regional household consumption of commodity *j*, R_j is the final demand not associated with households, α is an estimated parameter between 0 to 1 representing the portion of household consumption (e.g. final demand) contributing to freight movements. It is usually set to zero or a very small number.

Generating the Origin-Destination Matrix

The O-D matrix combines the intraregional and interregional flows. The model uses a standard gravity model to distribute annual freight tonnage between origins and destinations for the 9 commodity groups on the East Coast. The impedance variable for trip distribution is the distance between zones. The distance decay coefficient values for freight trips are calibrated to minimize the difference between the "observed" and "estimated" freight trip productions (Cho et. al. 1999, Gordon and Pan 2001). Coefficients are calculated for nine freight sectors. These are applied to the truck and train trips associated with commodity flows for the given sector.

We then could distribute inter-regional commodity flows to a limited number of zones or entry/exit points: the three major ports; major rail yards and highway entry-exit points. A variety of data sources is required to distribute the inter-regional flows to these entry/exit points. Unfortunately, some data sources are just not available.

To generate the O-D matrix of these inter-regional flows, we propose to use an algorithm developed by Giuliano et al 2010. Once the intra-regional freight trips are distributed, inter-regional freight trips can be distributed based on the attracted trips at internal TAZs. The following formula can be used to distribute the internal-external freight trips:

$$F^{Eo,d} = \sum_i Inb_i^{Eo} \frac{A_i^d}{\sum_d A_i^d} \tag{4}$$

$$F^{o,Ed} = \sum_i Outb_i^{Ed} \frac{P_i^o}{\sum_o P_i^o} \tag{5}$$

Where,

$F^{Eo,d}$ are freight trips from regional entry-exit point to internal TAZ *d*, *Eo*

$F^{o,Ed}$ are freight trip from an internal TAZ *o* to a regional entry-exit point , *Ed*

Inb_i^{Eo} are inbound commodity *i* at regional entry-exit point , *Eo*

Out_i^{Ed} are outbound commodity *i* at regional entry-exit point , *Ed*

A_i^d and P_i^o are the attraction of commodity *i* at zone *d* and the production of commodity *i* at zone *o*, respectively.

4. Conclusions

This research is an ongoing project on estimating the commodity flows for non-bulk freight on the East Coast corridor rail and highway networks in Australia. We first provided an overview of the issues and the modelling approaches found in the literature so as to estimate the freight generation. Particular attention has been given to the issues arising from data constraints for modelling freight demand generation. From this overview, it can be concluded that IO formulations can be successfully applied to modelling of freight flow movements. The existence of private and public information that focus on assembling both the economic data for IO analysis and commodity flows should translate into cost savings. This study therefore sets up a methodological framework for the estimates of regional freight movement using commodity flows and IO coefficients by describing the extension and refinement of the already existing framework in the Australian context, in this case the Sydney-Melbourne Corridor. However, this framework does require a significant amount of data. Some of the required statistical information is simply not available from the existing database.

The structure of the proposed approach has the potential to facilitate analysis and comparison of different scenarios, for example the impacts of expanded international trade, of increased highway or facilities congestion, the contribution of trucking to highway congestion, the relationship between employment location and commodity flows, etc. Although our research focuses initially on the Sydney-Melbourne corridor, our approach will have the transferability across other transport corridors. The computational framework will be the same, and most of our data sources have a national scope. We would only need to add selected sources specific to a particular corridor. Our main data sources are regularly updated, which will make updating and scenario generation easy and efficient. We hope that our work provides a tool that will allow regional planners and policymakers to make better and more informed decisions.

In our proposed framework, we use fixed technical and trade coefficients. Generation and distribution of freight demand is not sensitive to changes in transport cost and time. To make freight generation dependent on transport times and cost, the technical and trade coefficients in the IO model need to be elastic (with time and cost, e.g. in a logsum variable from mode choice as explanatory variable), as in the Italian national model. This will be our future research task.

5. References

Alstadt. B and J. Coughlin. (2012). Driving the Train: A Macro-based Framework for Commodity Forecasting. Paper presented at the Transportation Research Board, Annual Meeting, January 2012.

Bureau of Transport and Regional Economics (2003). Freight Between Australian Cities 1972 to 2001. Information Sheet 22. Canberra.

Bureau of Transport and Regional Economics (2006). Freight Measurement and Modelling in Australia. Canberra.

Brocker, J. (1998). 'Operational spatial computable general equilibrium models'. *The Annals of Regional Science*. 32(3): 267-387.

Cambridge Systematics, Inc (1996). Quick Response Freight Manual Final Report. prepared for the Federal Highway Administration. Washington D.C.

Cho S, Gordon P, Moore JE, Richardson HW (2001). 'Integrating transportation network and regional

economic models to estimate the costs of a large urban earthquake'. *Journal of Regional Science* 41(1):39–65
Cascetta, E. (1997). National Modelling in Italy: Simulation and Evaluation Models for the Italian DSS. Paper presented at Seminar on National Transport Models: The State of the Art, Noordwijl.
De Jong, G.; Gunn. H.F. and Walker, W. (2004). 'National and international freight transport models: an overview and ideas for further development. *Transport Reviews*, 24 (1):103-124.
DOT 2009
Elaurant.S, Ashley.D and Bates.J (2007). Future Directions for Freight and Commercial Vehicle Modelling. Paper presented at the 30th Australasian Transport Research Forum, September 2007, Melbourne.
Ernst & Young (2006). North-South Rail Corridor Study. Report for the Department of Infrastructure and Transport, Sydney.
EXPEDITE consortium (2000). Review of European and National Passenger and Freight Market Forecasting Systems. Deliverable l2 for the European Commission DGTREN, HCG. The Hague.
Federal Highway Agency (1999), Guidebook on Statewide Travel Forecasting. The Centre for Urban Transportation Studies, University of Wisconsin-Milwaukee.
Flagstuff consulting (2000). Aspects of the Greater Melbourne Fright Task. Reports commissioned by the Department of Infrastructure for the Victorian Freight and Logistics Strategy. Melbourne.
Federal Railroad Administration and U.S. Department of Transportation (2010). National Rail Plan: Moving Forward. Washington, D.C.
Greets, J.F. and G. Jourguin (2000). Freight transportation planning on the European multimodal network: the case of the Walloon region Proceedings of the 6th RSAI World Congress, Lugno, Switzerland.
Jack Faucett Associates (1999). Research and Development of Destination, Mode and Routing Choice Models for Freight. Final Report, Prepared for the DOT SBIR Office, DTS-22.
Jonnavithula, S.S. (2004). Development of Structural Equations Models of Statewide Freight Flows. *Theses and Dissertations.* Paper 1099, University of South Florida.
Giuliano, P. Gordon, Q. Pan, J. Park and L. Wang (2010). 'Estimating freight flows for metropolitan area highway networks using secondary data sources,' *Networks and Spatial Economics,*10 (1): 73-91
Gordon P, Pan Q-Sh (2001). Assembling and Processing Freight Shipment Data: Developing a GIS-Based Origin–Destination Matrix for Southern California Freight Flows. National Center for Metropolitan Transportation Research.
Holguin-Veras, J. List, G.F. Meyburge, A.H, Ozbay, K, Passwell, R.E, Teng, H and Yahalom, S. (2001). An Assessment of Methodological Alternatives for A Regional Freight Model in the NYMTC Region, Prepared for New York Metropolitan Transportation Council, New York.
Horowitz A. J. and D.D. Farmer (2000). A Critical Review of Statewide Travel Forecasting Practice
Liu, L.N and Vilain. P. (2002). Estimating Commodity Inflows to a Substate Region Using Input-Output Data: Commodity Flow Survey Accuracy Test. Research and Innovative Technology Administration.
Luk, J., and Chen, B. (1997). Evaluation of Information Available to Assess Road Freight Transport. Research Report ARR 308, ARRB Transport Research.
Mitchell, D. (2010).Trends in Non-urban Road Freight Using Weigh-in-motion (WIM) data. Proceedings at the Australasian Transport Research Forum 2010, 29 September – 1 October 2010, Canberra.
Pendyala, R.M., V.N. Shankar and R.G. McCullough (2000). Freight Travel Demand Modelling: Synthesis of Research and Development of A Framework. Transportation Research Record, No. 1725, TRB, National Research Council, Washington, D.C.
Railway Technical Society of Australasia (RTSA) (2012). Rail Horizons. No. 54. Summer.
Sorratini, J. and R.L. Smith (2000). Development of a Statewide Truck Trip Forecasting Model Based on Commodity Flows and Input-Output Coefficients. Transportation Research Record, No. 1707, TRB, National Research Council, Washington, D.C.
Strategic Design Development (2004) Input and Output Freight Generation South East Queensland. Report prepared for the Queensland Department of Transport and Main roads, Sydney.

Tavasszy.A (1994). Characteristics and Capabilities of Dutch Freight Transportation Systems Models, Rand report MR-382-EAC/VW, RAND Europe, Leiden.
Tavasszy, L.A. , M.J.P.M Thissen, A.C. Muskens and J. Oosterhaven (2002). Pitfalls and Solutions in the Application of Spatial Computable General Equilibrium Models for Transport Appraisal. Paper presented at the 42nd European Congress of the Regional Science Association, Dortmund.
Tavasszy, L.A. (2006). Freight Modelling- An Overview of International Experience. Paper presented at the TRB conference on Freight Demand Modelling; Tools for Public Sector Decision Making, September 25-27, Washington, D.C.
Transport Research Board (2008). Forecasting Statewide Freight Toolkit. NCHRP report 606. Washington D.C.