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Contestability between Road and Rail for Non-bulk Freight

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CRC for Rail Innovation Floor 23, HSBC Building Brisbane Qld 4000 GPO Box 1422 Brisbane Qld 4001 Tel: +61 7 3221 2536 Fax: +61 7 3235 2987 www.railcrc.net.au	**Document:** **Title:** Contestability Between Road and Rail for Non-Bulk Freight **Project Leader:** Robert Weatherby **Authors:** Robert Weatherby, Stuart Reid, Jian Wang **Other project team contributors:** Michael Charles **Project No.:** R1.135 **Project Name:** Contestability Between Road and Rail for Non-Bulk Freight

Synopsis:

This scoping study is a first step in determining a way to examine contestability of freight flows to rail and road in Australia. It The study reviews current freight and commodity modelling practice to identifying the most effective model for further study. A four-step commodity flow approach was first identified being most suitable and a proposed model was scoped. However, lack of available data made the preferred model impractical. The relatively new spatial computable general e(SCGE) model is recommended as the most suitable alternative approach; it requires less data than the four-step commodity flow approach and performs well in technically. It is proposed to test this model for determining non-bulk freight contestability for the East Coast corridor that links Melbourne and Brisbane. This scoping study includes extracts from a proposal for a full study to be undertaken under the leadership of Professor Edward Chung.

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Executive Summary

This scoping study explored ways to determine which non-bulk freight is contestable by rail in Australia. In determining contestability, it is necessary to ask:

- Where do road and rail compete for freight?
- What are the major economic drivers behind commodities, freight movements and modal choice?
- How large is the market where road and rail can compete in absolute terms and relative to the size of the total domestic freight task?

This project was the scoping study for a wider Freight Modal Choice Study application to the CRC for Rail Innovation.

For this scoping study, 'non-bulk freight' is defined as freight capable of being moved by container and items that can be moved on pallets in vans (box cars) and in motor vehicles in specialised carrier wagons.

This report study reviewed of current literature on methods for estimating freight movement and mode choice in a corridor. Understanding why and where freight moves, and who moves it, is critical for understanding mode choice, and ultimately for infrastructure investment, land-use planning and logistics policies to boost Australia's economic performance. The study also reviewed the existing evidence on factors that influence modal choice and identified current freight modelling practice, evaluating practicalities of different approaches to determining contestability between rail and road for non-bulk freight.

Few studies have attempted to systematically establish a relationship between mode choice and freight demand. The main reason is because of the difficulty of collecting the necessary data. Therefore, the influence of demand characteristics on freight mode choice has not been sufficiently understood. In fact, demand characteristics such as the attributes of the shipper, the attributes of the goods to be transported, and the spatial attributes of shipments, all strongly influence modal choice. Any change in these characteristics can make shippers' demand for transport services change considerably, often leading to choosing a new transport mode.

This study reviewed various freight modelling tools and methodologies. Three groups of modelling methods have been used extensively and are generally able to respond to the policy and analytical needs of freight modelling:
- vehicle-based models focus on modelling commercial vehicles trips
- commodity-based models commodity-flow matrices and converted numbers of trucks and trains based on static factors derived from past experience
- a range of inter-agent interaction approaches including integrated economic activity models.

Some proprietary products and newer approaches such as the spatial computable general equilibrium (SCGE) model were also reviewed for their potential applicability.

The review revealed almost no literature that considers individual market sectors or commodities for influencing factors across modes. Most literature addressing modal choice considers influencing factors that relate to intermodal or bulk freight. The literature highlighted that bulk freight cargoes are less constrained by timeframes and that bulk shippers are more experienced with non-road modes, compared to shippers in the general freight market. No sources dealt with individual non-bulk markets, although individual non-bulk markets were sometimes mentioned in overall market studies. Consequently, a mode choice study examining commodity flows over different corridor distances and mode options is needed to determine the types of freight that are contestable and to inform sound regulatory and policy decisions in the Australian freight market.

Examining the contestability of non-bulk freight between competing land transport modes involves selection of a suitable corridor for analysis and selecting suitable modelling methods. To select a suitable freight corridor, several factors were considered including current mode share, potential for change in mode share, the level of

analytical and modelling complexity, and the potential to obtaining practical results. Given these considerations, the East Coast corridor (Melbourne–Sydney–Brisbane) was chosen as the case study corridor.

An appropriate model must be able to determine the existing freight rail could successfully carry. Of the existing modelling techniques, two alternative methods were the most suited to the task: the four-step commodity-based approach and the SCGE approach.

The four-step commodity-based approach was initially selected as the preferred technique and a framework and forecasting tool were scoped. Under this approach, a commodity-flow database would provide information about freight by origin, destination, commodity, and mode of shipment and tonnage to, from, and within the East Coast corridor. However, the four-step commodity flow framework required considerable data input that is not readily available within Australia. A commodity flow database would require many mode-specific data sources to create a picture of the East Coast corridor's freight traffic flows on a market-to-market commodity basis. Although it may be possible to combine different data sources, or to acquire the data through mechanisms such as vehicle-on-road intercept surveys and operator surveys, the time to complete the project (data collection, recruit personnel with appropriate expertise) would exceed the Cooperative Research Centre's (CRC) timeframe. It is estimated that it could take up to two years to obtain the necessary data. Therefore, the four-step commodity-based approach was deemed to be inappropriate for this project given the data limitations. The SCGE approach does not require as much data. With the expertise available at the Smart Transport Research Centre at the Queensland University of Technology, led by Professor Edward Chung, a full proposal using an SCGE-based model has now been developed.

This scoping study also identified is a lack of information about the factors that influence mode shift, which has important practical implications. When contestable freight types are identified, the next step for the rail industry is to actually achieve modal shift to rail. A number of factors, such as service quality, reliability and logistics may influence the mode choice of shippers and carriers. These factors may be barriers to shippers switching from road to rail, constricting rail's potential to obtain a larger share of contestable freight. Yet a detailed understanding of the factors that influence mode choice is not available. There are few examples of addressing behavioural elements in freight modelling in the published literature. This gap in the research means policy makers cannot have a full appreciation of the barriers relating to different sectors and commodities for mode choice. In practice, this lack of understanding undermines the capacity to actually achieve modal shift in contestable freight.

As a part of any project to determine contestable freight, the barriers to actually capturing mode shift need to be identified. It is proposed that, as well as developing the SCGE model, that semi-structured interviews are conducted with freight forwarders and major industrial shippers of consumer-based goods. These interviews should obtain information about shippers' interactions with rail freight operators compared to their interactions with road freight operators in an attempt to pinpoint specific areas where the rail freight industry may need to improve to capture contestable freight. On the completion of the project, rail operators will be empowered by information be able to challenge the trucking industry on freight movement performance issues.

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Abbreviations and Acronyms

ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
AFS	Australian Freight Survey
ARTC	Australian Rail Track Corporation
AusLink	previous Australian Government Infrastructure body
BIE	Bureau of Industry Economics
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BTCE	Bureau of Transport and Communication Economics
BTE	Bureau of Transport Economics
BTRE	Bureau of Transport and Regional Economics
CFS	Commodity Flow Survey
CRC	Cooperative Research Centre
ECFM	East Coast Freight Model
EE	External–External
EI	External–Internal
FMCG	Fast Moving Consumer Goods
FMS	Freight Movement Survey
FRA	Federal Railroad Administration
GA	Genetic Algorithm
GDP	Gross Domestic Product
GIS-T	Geographic Information System for Transport
GOODE	Genetically Optimised O–D Estimation
GM	Gravity Model
IE	Internal–External
II	Internal–Internal
I–O	Input–Output
LUTI	Land Use Transport Interaction
MFMM	Melbourne Freight Movement Model
NCHRP	National Cooperative Highway Research Program
n.e.s.	Note Elsewhere Specified
NLTN	National Land Transport Network
OESR	Office of Economic and Statistical Research
O-D	Origin-Destination
PBA	Peter Brett and Associates
PCE	Passenger Car Equivalence
PWC	Production–Wholesale–Consumption
ROA	Rest of Australia
RTSA	Railway Technical Society of Australasia
RUBMRIO	Random Utility-based Multi-Regional Input–Output Model
SCGE	Spatial Computable General Equilibrium
SMILE	Strategic Model for Integrated Logistics Evaluations
SMVU	Survey of Motor Vehicle Use
SPE	Spatial Price Equilibrium
SRA	Strategic Rail Authority
TAZ	Traffic Analysis Zone
TERM	The Enormous Regional Model
USCFS	US Commodity Flow Survey
WIM	Weight-in-Motion

Introduction

Background

The East Coast corridor (Melbourne–Sydney–Brisbane) incorporates Australia's largest and most populous capital cities and urban centres; it contains Australia's major manufacturing centres, its largest ports and most of the national population. Consequently, it also has the greatest degree of road congestion. Yet rail performs only a small role, in the transporting 22 per cent of general freight between the major centres along the corridor. The rail freight sector has achieved in both the East–West (Sydney/Parkes/Melbourne/Adelaide to Perth) and the North–South Corridor (Adelaide–Darwin), compared to the EastCoast Corridor (Booz Allen & Hamilton, 2007).

Non-bulk freight, including semi-processed and manufactured goods, is not seen as a key priority for rail (RTSA, 2012). There is a need to better understand the types, values and economic importance of non-bulk freight movement to, from and within the East Coast corridor and the issues for contestability between rail and road.

The Australian domestic freight task has doubled in size over the past two decades, growing at an average annual rate of 3.5 per cent. The Bureau of Infrastructure, Transport and Regional Economics (BITRE) predicts that this trend will continue, although with slightly slower growth of about three per cent annually until 2030. In 2007, 35 per cent of Australia's domestic freight was moved by road; 40 per cent was transported by rail; 25 per cent was moved by coastal shipping; and less than 0.1 per cent was transported by air (BITRE, 2009). Road was the main form of freight transport for most inter-capital city corridors, while rail dominated the East–West corridor, shifting just over half of non-bulk freight (Toevai, 2009).

At its most basic, freight is defined as goods transported from an origin to a destination (NCHRP, 2008). Freight movement is not an end in itself; its purpose is to ensure that products reach a location where they can be consumed. For this reason, demand for freight is considered a derived demand rather than a primary demand: the demand for freight is derived from the geographic distribution of production and consumption. Therefore, the 'production–consumption' definition is essential for making forecasts of change in freight activity because it is the only way to predict growth at the two ends of the freight's movement (Elaurant, Ashley & Bates, 2007).

The choice of mode used to move freight is, therefore, dependent on the type and location of economic activities behind the consumption and production. Shippers' choice of transport mode involves consideration of cost, reliability, duration and frequency of services, the characteristics of the goods being moved, and the availability of transport capacity. The questions for determining contestability are:

- Under what circumstances do road and rail compete for freight?
- What are the major economic drivers behind commodities' freight movement and modal choice?
- How large is the market in which road and rail can compete in absolute terms and relative to the size of the total domestic freight task?

Estimates and projections for freight movements and data on freight transport contestability between rail and road are unreliable; cohesive data sets across the contestable freight sector are not available. The rail industry is keen to better understand the key variables affecting demand for non-bulk freight, and ultimately the potential for non-bulk intermodal rail freight movements into the foreseeable future. The purpose of this study is to propose a modelling solution that will enhance the capability of the rail industry to analyse and determine contestability of non-bulk freight.

For this study, 'non-bulk freight' is defined as freight capable of being moved by container and items that can be moved on pallets in vans (box cars) and in motor vehicles in specialised carrier wagons. Non-bulk freight is not the same as intermodal freight, which is regarded as containers only.

Scope

This scoping study includes a review of the current literature on estimates of corridor freight movement and mode choice. Understanding why and where freight moves and who moves freight is critical for understanding freight corridor mode choice, and, ultimately, is essential to informing transport infrastructure investment, land use planning and logistics policies to boost Australia's economic performance.

This study reviews reviewed existing evidence on factors that influence modal choice and identified current freight modelling practice and evaluates the practical aspects of undertaking study to determine contestability between rail and road for non-bulk freight. This project was the scoping study for a wider Freight Modal Choice Study application to the CRC for Rail Innovation.

1. Literature review

1.1. Why does freight move?

Freight demand is a function of regional, national, and international economic and demographic characteristics, operational factors, infrastructure, public policy and regulations, and environmental factors. As a result, changes in any factor can cause changes in some or all of the other factors, and can also impact the quantities and method of transporting freight (Cambridge Systematics, 1997). Infrastructure, public policy, and environmental factors have an indirect impact on freight demand. Economic, demographic, and operational factors have a more direct impact on freight demand. Figure 1-1 illustrates the relationship and interactions between the factors that influence freight demand.
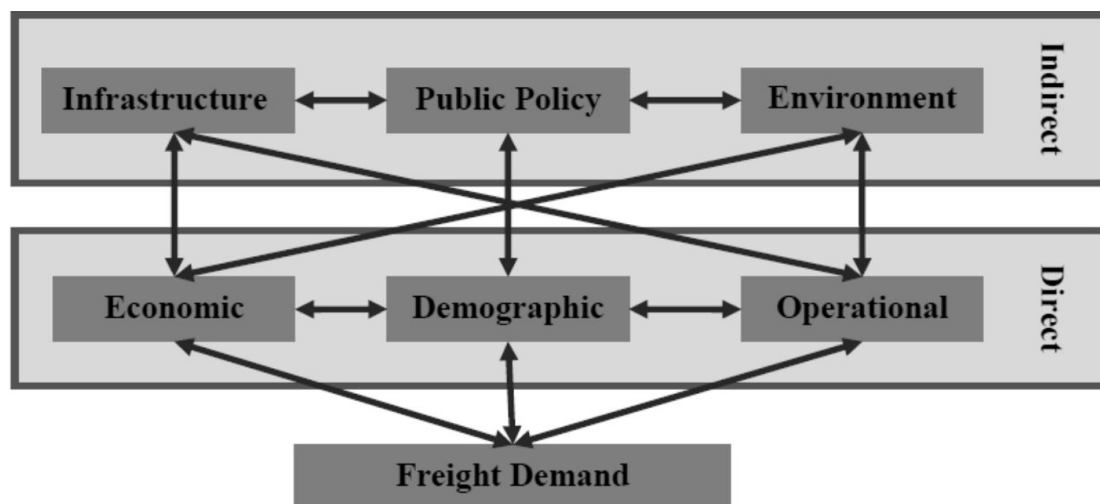
Figure 1-1: Categories of factors influencing freight demand (demand side)
Source: Prozzi et al., (2011)

As a derived demand, the demand for freight is primarily influenced by the volume of goods produced and consumed. Expansion in the national economy, or the economy of any region, results in increases in overall demand for goods and services, while economic contractions result in demand reductions (Cambridge Systematics Inc., 1996). Broad economic factors that influence demand also include inventory practices, carrier shipper alliances, fuel and energy costs, and international trade. Change to any of these factors could potentially have a direct impact on the amount and movement of freight in a region or at the national level (Horsley, 2007). Similarly, demographic factors, such as the size and density of the population, education and income characteristics, age distribution, and employment status, influence consumption and the destination and volume of freight moved (Sivakumar & Bhat, 2000).

Many operational factors impact on the volume of freight that can be moved and the cost of freight transport, directly influencing freight demand. Operational factors include mode characteristics, mode capacities, service availability, service frequency, operating schedule, reliability, technology and electronic data interchange, cost, travel time, travel distance, fuel consumption by mode or route, and modal connectivity (Prozzi et al., 2011).

The capacity of freight transport infrastructure affects not only the volume of freight that can be moved, but also the cost of freight transport, which ultimately impacts on the economy of a region or nation (Prozzi et al., 2011). In contrast to the direct impact of economic, demographic, and operational, infrastructure factors indirectly impacting freight demand through service levels and costs (Horsley, 2007).

Public policy also indirectly influences on freight demand. Examples of public policy factors include: government funding or operating subsidies, arrangements for coordinating freight planning and promotion, policy and regulatory relating to safety or the environment, the conditions for access to public infrastructure, and user charges and other taxes (Prozzi et al., 2011).

Environmental factors also indirectly influence freight demand. In recent years, Australia has started to recognise the importance of sustainable development. Environmental factors that can potentially impact freight demand include more fuel-efficient equipment and modes, such as hybrid locomotives and rail itself (CRC for Rail Innovation, 2009). Environmental considerations may also be reflected in public policy and regulation, such as the implementation of the carbon tax.

1.2.   Who moves freight and how?

Freight transport decision making is significantly more complex than the decisions made for passenger transport. Freight transport is only one element of complex supply chains. Freight decisions tend to be made as a result of commercial negotiations involving relatively small numbers of businesses or individuals (PBA, 2010).

1.2.1.   Influencing factors on mode choice

A number of studies on mode choice factors have been undertaken since the 1980s, both in Australia and overseas. On the supply side, the principal explanatory variables included in literature are service variables (Fowkes & Tweddle, 1988; Widlert & Bradley, 1992), including:
- transport costs
- transit time
- frequency and reliability
- damage rates.

Ellen, Meyer and Wilson (1985) reported that the choice of hired trucks can be enhanced through greater cooperation between shippers and carriers, and when pick-up services are provided by the carrier. The pick-up services were the most important factor when choosing to hire a truck. Transit time and reliability of transit time were important factors in the decision to use private trucks. Young et al. (1982) found for manufactured goods, enhanced reliability, lower freight rates, decreased damage, and improved communication were effective in increasing rail modal share, while for non-manufactured goods, enhanced capacity and lower freight rates were effective in increasing rail modal shares. The Bureau of Industry Economics (BIE) (1992) stated that price and timeliness and reliability were the most important issues for users of rail freight services in Australia. Reliability of rail services was of prime importance for non-bulk (general) freight shippers, but was not so important for bulk freight shippers.

Reliability includes many factors, including transit time compared with road, on-time performance, availability of wagons, and terminal performance.

In a survey of Australian freight forwarders conducted by the Bureau of Transport and Communication Economics (BTCE) (1996), respondents were asked to rank rail service characteristics in order of importance for determining service quality. The seven highest ranked determinants were:
1. punctuality of trains
2. cargo damage
3. terminal efficiency
4. wagon availability
5. service as a percentage of the number of wagons scheduled to be available to customers
6. short-shipping
7. billing errors.

Cambridge Systematics Inc., (1995) concluded that mode choice was determined by the perceived cost of the total logistics for using the various modes or practical combinations for given shipments. They suggested that any change in the total logistics cost for a particular mode could result in diversion to/ or from a competing mode.

Nam (1997) found transit time to be the most important factor in mode choice for all commodity groups, while shipping rates were important for rail users and accessibility was important for truck users. Similar to Nam (1997), Jiang, Johnson and Calzada (1999) and Sivakumar, Srinivasan and Bhat (2001) found transit time to be an important variable affecting the choice of mode — inversely related for trucks and directly related for rail. This finding implies that rail is preferred for longer-haul shipments. In addition, transit time and pick-up services were significant factors for rail mode choice. Howie and Nelson (1998) found that, for general containerised freight, a 10 per cent reduction in rail costs resulted in a 9 per cent increase in market share and that price was a significant factor affecting mode choice. Danielis and Rotaris (1999) reported that a number of UK studies found transit time to be an important factor in freight mode choice. Other significant factors were reliability, flexibility, and intermodal connections.

In a study on freight in Australia, BIS Shrapnel (1999) identified the importance of service quality factors for the selection of freight transport suppliers is relatively consistent across the types of freight it assessed. Typically, the most important factors customers considered in selecting and assessing suppliers were:
- reliability of delivery and pick up (on time)
- care of goods
- ability to respond to customer needs
- proactive notification of problem.

Woodburn (2004a) illustrated that a range of factors affect switching consignments from road to rail, including service quality, reliability, supply chain infrastructure and design. In particular, the evolution of logistics systems is constricting rail's potential because it lags behind road in providing the necessary service levels to meet supply chain partners' demands. Woodburn (2004b) assessed the reasons for rail being either successful or unsuccessful for specific flows, particularly for fast moving consumer goods (FMCGs) and other 'premium logistics' products, and analysed the role of rail

freight within contemporary supply chains. The report makes the following comments that are relevant to this review:

> In many cases, rail and road are both utilised along particular corridors or for particular flows, with rail catering for the relatively predictable flows and road handling individual and ad hoc consignments, particularly ones arranged at short notice… In addition, rail seems to perform best where it has been actively incorporated into the supply chain at the planning stage or where it has a natural distance and/or volume advantage over road, as in many of the other examples. (Woodburn, 2004b, p. 59)

Endemann and Ballungsraum (2009) reported the findings of surveys of shippers looking at barriers to modal shift in the Frankfurt Rhine–Main region of Germany. For half the shippers, transport costs were identified as the crucial criteria for choosing a haulage company. Other decisive criteria were duration of transport, time reliability and temperature conditions. The barriers to modal shift identified hold some relevance for the Australian market. In particular, Endemann and Ballungsraum (2009) acknowledge that even where rail freight potential exists along a corridor, it requires both a wagon-load service and logistics changes to induce modal shift.

From the literature that has been reviewed, a variety of determinants were observed for selecting both service provider and mode. Table 1-1: lists these determinants (factor 1) and measure of these determinants (factor 2) for them. A general model that is applicable to any freight transport task will need to consider these types of determinants, recognising that their weighting and assigned value will vary between tasks.

Table 1-1: Mode choice determinants across freight modes and tasks, as identified from literature sources

Factor 1	Factor 2
Total logistic costs	Transport charges
	Capital carrying costs in transit
	Service reliability costs
Modal characteristics	Trip time and reliability
	Capacity
	Equipment availability
	Handling quality
	Customer service
Spatial distribution of shipments	Distance of shipment
	Shipment frequency

1.2.2. Summary

On the demand side, few studies have attempted to systematically establish a relationship between mode choice and freight demand characteristics. The main reason for the absence of freight demand analysis is the difficulty in collecting the necessary data (Ortuzar & Willumsen, 1994; Bunker, 2001). Therefore, the influence of demand characteristics on freight mode choice has not been sufficiently studied, and is not well understood. In practice, however, demand characteristics, such as the attributes of the shipper, the attributes of the goods to be transported, and the spatial attributes of shipments, strongly influence modal choice. Any change in these characteristics can substantially alter shippers' demand for transport services, often resulting in the choice of a new transport mode (Jiang et al., 1999).

The review of the literature revealed there is almost no literature that considers individual market sectors or /commodities for influencing factors across modes. Most literature addressing modal choice considers influencing factors that relate to intermodal or, in some cases, bulk freight. For bulk freight, the literature generally highlighted that bulk freight and bulk cargoes are less constrained by timeframes and that shippers of bulk freight are more experienced in non-road modes compared to shippers of general freight (PBA, 2010). No identified sources dealt with individual non-bulk markets, although these types of market were sometimes mentioned in overall market studies.

In the case of rail, a series of Strategic Rail Authority (SRA)[1] market reports were produced in the United Kingdom in 2004. These market reports consider the rail opportunities for aggregates, automotive, coal, general freight, metal, petroleum products and waste (see SRA, 2004). SRA (2004) argued that, for general freight (non-bulk freight), the markets are neither clearly defined nor well understood. An earlier SRA Rail Freight Survey from 2003 (SRA 2003) also considered bulk markets (i.e.,, primary and manufactured) and examined levels of satisfaction from rail users. In the United States, the Federal Railroad Administration (FRA) and the US Department of Transport (USDOT) issued the *National Rail Plan: Moving Forward* (FRA & USDOT, 2010). This report included informative tables about the potential modal comparative advantages, by market, for passengers and freight. This report found that rail was an advantageous mode for transporting both bulk and non-bulk ('moderate') freight over relatively short distances. Table 1--2 provides the potential modal comparative advantages by freight market.

Table 1--2: Potential modal comparative advantage by freight market

Intercity distance in miles					
	0–250	250–500	500–1000	1000–2000	>2000
Light: retail goods	Truck	Truck	Truck, rail Intermodal	Truck, rail intermodal	Truck, rail intermodal
Moderate: consumer durables and other manufactured goods	Truck, rail	Truck, rail, rail intermodal	Truck, rail, rail intermodal	Truck, rail, rail intermodal	Truck, rail, rail intermodal
Heavy: bulk goods	Truck, rail, Water	Rail, water, truck	Rail, Water	Rail, water	Rail,

Source: FRA and USDOT 2010, p.17

In addition, there is little published literature that addresses behavioural barriers and other factors by market segment (commodities) across rail and road modes. As a consequence of this gap in the research, policy makers are unable to have a full appreciation of the nature and variety of barriers that might be pertinent to different sectors or commodities, and whether there are common characteristic themes to these barriers.

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[1] In existence from 2001 to 2006, the Strategic Rail Authority (SRA) was a non-departmental public body in the United Kingdom set up under the *Transport Act 2000* to provide strategic direction for the railway industry. Its functions were transferred in 2006 to the Department for Transport (for further information see: UK Government, 2012).

Within the Australian context, there is a common view that rail is only competitive in the long-distance bulk freight, task for carrying bulk commodities such as iron ore and coal, while road dominates middle distance, non-bulk freight on most defined National Network[2] corridors, including the shorter distance inter-capital corridors. This dominance is said to be due to road's flexibility over rail and its significantly better on-time performance. The only inter-capital corridors where rail dominates are the longer distance Melbourne-–Perth and Adelaide-–Perth corridors (BTRE, 2003; 2006b) as well as the Adelaide–Darwin corridor. However, there does not appear to be any empirical research that tests the validity of the view that rail is only competitive for long distance, bulk freight. Given the considerably shorter distances identified in the North American mode allocation study (FRA & USDOT 2010), and the current gap in research applicable to the Australian context, a mode choice study that examines commodity flows over different corridor distances and mode options is needed to inform sound regulatory and policy choices in the Australian freight market.

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2 The National Land Transport Network (National Network) is defined in the *Auslink (National Land Transport) Act 2005* National Land Transport Network Determination 2005 (No.1). The National Network forms an integrated network of land transport networks of strategic importance. It comprises national and inter-regional transport corridors linking urban areas, ports, airports, road, rail and intermodal connections. The development and enhancement of the National Network is jointly funded by the Australian Government and respective state governments (Australian Government, 2012).

2. Freight and commodity modelling practice for contestability of freight

2.1. Introduction

Transport forecasting is generally about the process of estimating the level of usage for a specific transport facility into the future. Several different modelling approaches and a variety of analytical tools are used for this task. In all cases, considerable data gathering is required.

Accurate forecasts are critical for determining the right capacity for transport infrastructure and services, to meet the demand over a given period. In recent decades, there has been a growing demand for freight modelling to practically inform policy (Elaurant, Ashley, & Bates, 2007; Tavasszy, 2006). As Cambridge Systematics Inc. and GeoStats (2010, p. 1) point out, 'Given the growth in freight and its importance to national, state, and regional economies, public-sector agencies need improved capabilities to analyse freight demand'.

Tavasszy (2006, pp. 2-3) and Elaurant et al. (2007) describe the types of emerging issues that are fuelling a growing demand for freight modelling to inform policy. These include:
- the emergence of the 24-hour economy
- growth in freight volumes
- concerns about freight traffic congestion
- concerns about environmental impacts
- concerns about the possible impacts of insufficient capacity and impacts on international competitiveness
- concerns about security and safety (Elaurant et al., 2007; Tavasszy, 2006).

According to Tavasszy (2006), these factors are driving a need for models with greater levels of detail and are driving an extension of freight modelling into the broader transport system both geographically and functionally to linking transport and the economy.

The methods of analysing freight traffic at a statewide level are similar to models used for predicting passenger travel. However, the development of freight forecasting techniques has lagged behind the development of passenger techniques (Elaurant et al., 2007; Tavasszy, 2006). For various reasons, it has been suggested that forecasting freight transport flows is more complex than modelling passenger travel volumes (Horowitz & 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 multiple modes. Lack of data can also complicate freight modelling (Elaurant et al., 2007).

Although freight modelling practice is an emerging field, freight modelling research has a long history and has developed in a number of directions (Regan & Garrido, 2002; Sivakumar & Bhat, 2002; Tavasszy, 2006). For example, Tavasszy (2006) described the evolution of transport models in the European context, commencing in the early 1970s with models focusing on the description of trade by using gravity tools; followed by introduction of input–output (I-–O) models and land use transport interaction (LUTI) models focusing on the links between trade, transport and the economy; and finally the introduction of mode choice modelling in passenger transport (see Table 2.1). During the 1980s, network modelling emerged to address trip generation, trade, mode choice and route choice, which are the components of the classical four-step models. In the 1990s, these classical, staged models were extended to include

consideration of multi-commodity contexts, probabilistic choice and inventory factors (Tavasszy, 2006). Tavasszy (2006) also pointed out that recent approaches have included freight network simulation, using micro-simulation or network modelling to describe the behaviour of different agents in the system. Another recent and related approach describes agent behaviour by applying game theory. More recently new, sophisticated forms of integrated economic activity modelling have also emerged.

Table 2-1: Evolution of Freight Modelling in Europe

Decision problem	Typical modelling challenges	Typical techniques employed		
Production and consumption	trip generation and facility location freight/economy linkage consumption patterns	LUTI ('70s) and SCGE ('90s) models	trip generation models, I/O (70's)	
Trade	international trade value to volume conversion		gravity models, synthetic O/D models ('70s)	agent based simulation models ('90s)
Logistics services	inventory location supply chain management considerations	logistics choice models ('90's)		
Transportation services	choice of mode intermodal transport light goods vehicles	simple trip conversion factors ('70s), discrete choice ('90s)	multimodal networks ('80s)	
Network and routing	routing and congestion tour planning city access	network assignment ('80s), simulation ('90s)		

Source: Tavasszy (2006), p. 5

The sequential and aggregate nature of transport forecasting has been a source of criticism for the existing models. Aggregation can be convenient, and necessary, owing to data limitations; however, it does also have drawbacks. For example, while gravity models can be very useful in explaining the choice of a large number of units, the choice of any given unit can vary greatly from the predicted value. In taking a disaggregated approach to understanding intercity freight flows, Winston (1981), for example, points out that aggregate models tend to obscure observed differences in shipper or receiver behaviour and that the drawbacks of aggregate approaches include, "an inability to define unique market elasticities as well as a failure to determine if a competitive interface between modes actually exists'.

The problem of land-use feedback has also been a source of criticism because transit investments not only respond to existing patterns of land use, but shape it as well. For instance, Sundberg (2009) states that reduced transport costs due to infrastructure investments will stimulate participants to take advantage of the cost reduction in both production and consumption, and these effects can be difficult to capture in economic modelling such as I–O models.

Evidence suggests that a significant number of forecasts have inaccurate for transport infrastructure planning (see Flyvbjerg, Skamris Holm, & Buhl, 2006). So, while there is a growing demand for freight modelling, the selection of appropriate methods, for each given case, must include an understanding of the different approaches, including their strengths and weaknesses.

2.2. An Overview of Modelling Approaches

There are different ways to classify, or group, the various models that have been applied to freight transport forecasting. Elaurant et al. (2007) classify freight transport models by their geographic scope and the degree of complexity with which they consider drivers of demand. Elaurant et al. (2007) describe models using Giamo's (2006) categories of:

1. undifferentiated — commercial and other vehicles are included with no special treatment;
2. commercial vehicle — matrix developed, for example, within a four-step model or matrix
3. estimation
4. commodity-based — commodity flow matrix developed and converted to mode traffic based on
5. static factors from past experience
6. integrated land use — commodity models with economic I–O model with feedback loops to
7. produce commodity flow matrix.

In discussing the state of research and practice, Cambridge Systematics Inc., and GeoStats (2010) employ several other groupings. Sivakumar and Bhat (2002) consider that freight modelling approaches fall into three broad groups:

1. trend analysis
2. classic four-step approaches
3. inter-agent interaction approaches.

According to Giamo (2006) and NCHRP (2008), interstate freight models may be classified as:

1. traditional truck modelling
2. 2) commodity-based methods
3. integrated economic activity models.

Traditional truck modelling and commodity-based methods are both staged approaches aligning with classical four-step approaches and integrated economic activity models broadly align with the inter-agent approaches. Figure 2.1 provides an overview of modelling approaches. The purpose of this classification is merely to provide a framework to aid discussion; it is not, as highlighted by the preceding discussion, the only classification that may be applied.
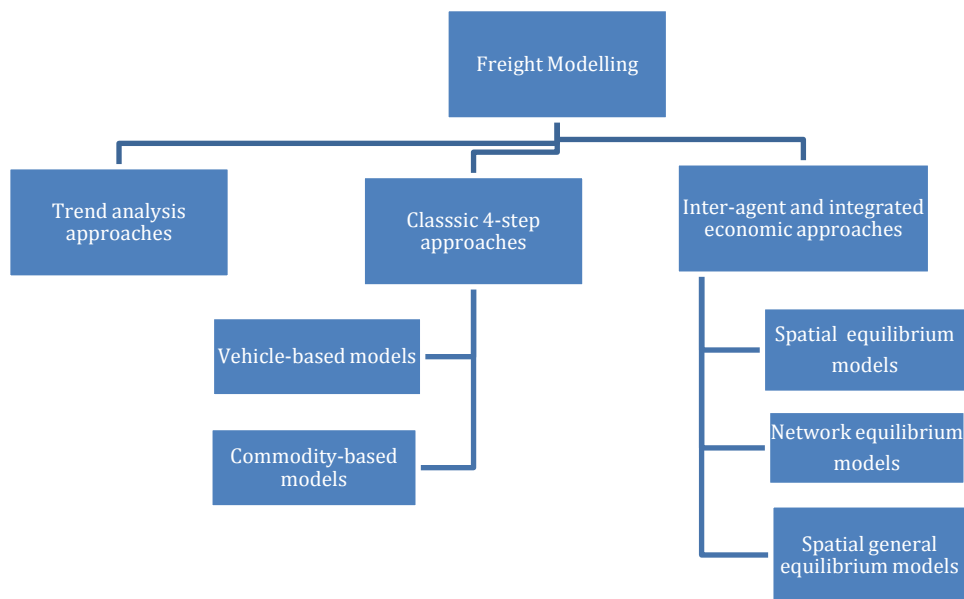
Figure 2.1 An overview of freight modelling approaches and models

Source: Figure adapted from classification system adopted in Sivakumar and Bhat (2002).

2.3.   Trend Analysis (or Time Series) Approaches

Sivakumar and Bhat (2002) point out that trend analysis (time-series) approaches examine current freight flow patterns, and the historical trend in freight flow patterns, to predict future flows (for example see Cambridge Systematics Inc., 1997). Cambridge Systematics Inc. and GeoStats (2010) observe that trend models can vary in sophistication, ranging from simple regression modelling established on past freight activity levels to more complex multivariate autoregressive models.

Trend analysis approaches offer advantages because they are conceptually straightforward; are not data-intensive, using readily available aggregate freight movement data; and are easy to implement (Sivakumar & Bhat, 2002). Trend analysis models are commonly used by public sector agencies (Cambridge Systematics Inc., & GeoStats, 2010).

However, time series approaches usually employ aggregate data and typically have the same limitations of aggregation. Furthermore, because time series approaches are based on historical data, they embody a static approach, assuming that the underlying economic conditions that influence freight demand remain the same. These approaches do not account for large shifts in economic forces affecting freight movements or changes in transport infrastructure, shifts that can influence freight volumes and mode choice (Cambridge Systematics Inc. & GeoStats, 2010; Sivakumar & Bhat, 2002).

2.4.   Classic Four-Step Modelling Approaches

In classic four-step modelling approaches, the region of analysis is typically divided into zones, by trend or regression analysis, and analysis tools are applied to the four steps:
   1.   Freight generation. This step determines the frequency of origins or destinations of trips, as a function of land uses and other socio-economic factors.

2. Distribution. In this step, origins and destinations are matched to develop an origin–destination (O–D) table. This stage of analysis often uses a gravity model to represent the macroscopic relationships between places, i.e., a relationship based on the concept that the interaction between two locations declines with increasing distance, time and cost between them ('friction factors'), but is positively associated with the amount of activity at each location.

3. Mode choice or modal split. This step computes the proportion of trips between each origin and destination that use a particular transport mode, allowing mode share to be determined.

4. Route assignment. This step allocates trips between an origin and destination, by mode, to different routes.

Sivakumar and Bhat (2002) state that four-step modelling approaches can use disaggregated (individual shipment) data or aggregated freight movement data, although research using disaggregated data has mostly been confined to the mode choice step. For example, Winston (1981) investigated mode choice in intercity freight using a disaggregate approach, examining the behaviour of the individuals making mode choice decisions. However, in practice, as Sivakumar and Bhat (2002, p. 3) point out, most freight planning efforts use aggregate data because disaggregate data is difficult to obtain. As a consequently, the traditional four-step modelling approach has difficulty capturing the factors that influence shipper and carrier behaviour as per Cambridge Systematics Inc. and GeoStats (2010, p. 9), so examples of freight behavioural modelling are relatively scarce. Understanding and modelling the logistics decisions that affect freight demand remains an important challenge (Cambridge Systematics Inc. & GeoStats, 2010, p. 9).

Classic four-step approaches can be further divided into two broad types: vehicle-based models and commodity-based models.

2.4.1. Vehicle-based Models (Traditional Truck Modelling)

Vehicle-based models (or traditional truck models) focus on truck traffic and use a classical staged approach, with the traditional steps of trip generation, trip distribution, and highway assignment. In the classical approach, as shown in Table 32.2, a gravity model accounts for variation in trip distances and is used to derive the trip generation component. Another gravity model is used to estimate trip distribution. Finally, network assignment is used to distribute the freight traffic across links (Alstadt & Coughlin, 2012). Different methods can also be applied to vehicle-based models. Sivakumar & Bhat (2002) observe that O–D flows can be estimated from traffic and screen counts, in what is called the O–D Synthesis approach.

Table 2.2:   Example of model components of vehicle based approaches

Step	Approach
Trip generation	Trip generation rates or zonal regression models
Trip distribution	Gravity models or intervening opportunities
Traffic assignment	Standard traffic assignment techniques

Source: Pearson et al., 2006

A problem with vehicle-based models is that they are not policy-sensitive because they cannot reflect changes in growth rates by commodity class (Sivakumar and Bhat, 2002). They also, 'fail to recognise that freight travel is related to commodity movement, not truck movement' (Sivakumar and Bhat,). Also, traditional truck

modelling does not have a mode choice modelling phase, because the truck trip is itself the result of a mode selection process that took place previously took place (Holguín-Veras et al., 2001). Therefore, this approach is not suitable for modal choice analysis or commodity flow analysis. However, Table 2-3 shows examples of applications for gravity models for vehicle-based modelling (see Table 3.3).

Table 2.3:   Examples of vehicle-based approaches

Source	Comment
Cambridge Systematics (1996)	Trip generation is performed by applying default trip generation rates to employment categories and households. Distribution is done using the gravity model with friction factors based on travel time or distance. Assignment is undertaken on the basis of passenger car equivalence (PCE).
Nellet et al. (1996)	Trip generation: two-stage destination choice model used with region-to-region flows from 1983 benchmark input–output accounts. Assignment: all or nothing using generalised travel cost.
Thornton Guensler, & Schropp (1998)	Generation: internal truck trips estimated using cross-classification of trip rates by two vehicle classes and land use employment categories. External truck trips estimated using regression equations for two classes of vehicles developed from external survey.
Sorratini (2000)	Trip generation: Commodity flow survey (CFS) and I–O coefficients used to generate truck flows. Truck trips disaggregated to the traffic analysis zone (TAZ) using zonal population. TRANSEARCH database's tons-per-truck data used to determine trips generated at each zone. Assignment: TRANPLAN gravity model used to distribute three trip types: (I–I, I–E, E–I) and Fratar Growth Factor model used to determine E–E allocation. Validity tested by comparing estimated truck flows to ground counts for selected network links.

2.4.2.   Commodity-Based Models

Commodity-based models predict the movement of commodity by class, and then translate commodity movements to vehicle traffic by mode (Sivakumar & Bhat, 2002). These models use the classical four-step methodology of trip generation, trip distribution, mode split and network assignment. Focusing on cargoes allows the models to capture the economic mechanisms that impact on freight movements (Pearson et al., 2006).

In the trip generation phase, trip rates by commodity are calculated using population or employment data as shown in Table 2.4. Commodity-based models typically start with a known region-to-region table of commodity flow tonnage determined based on economic output forecasts and regional trade patterns, or obtained from surveys (Holguín-Veras et al., 2001). The inbound and outbound flows are disaggregated to a zonal level (typically district or county) based on economic data that reflects intensity of production and consumption (e.g., zonal employment levels). Linear regression models, spatial I–O models (see for example Sorratini, 2000), or commodity rates are then used to predict commodity production and consumption levels for each analysis zone by commodity class (Sivakumar & Bhat, 2002). A gravity model formulation is

then used for trip distribution. Commodity flows are sometimes converted to trips after they are allocated to origins and destinations (i.e., flow tables are converted to trips) based on commodity-specific payload data. When commodity flows are assigned to origins and destinations, they are converted to trips by mode. Traffic assignment is undertaken using an all-or-nothing assignment technique (Sivakumar & Bhat, 2002).

Table 2.4:   Example of model components of commodity-based approaches

Step	Approach
Commodity generation	Commodity generation rates or zonal analysis
Commodity distribution	Gravity models or intervening opportunities
Commodity mode split	Logit model or historical mode shares
Traffic assignment	Standard traffic assignment techniques

Source: Pearson et al. 2006

Commodity-based models can produce weekday freight volumes on major freight flow facilities in a region and annual tonnage of commodities produced or consumed by mode, by zone (typically district or county), and by origin and destination (NCHRP, 2008). Most international statewide models tend to be sequential four-step models and commodity-based models. For example, Sivakumar and Bhat (2002) note that this approach is commonly used in statewide freight planning in the United States. Examples include statewide freight models in Indiana, Kansas, Michigan, Wisconsin, and Oregon.

Sivakumar and Bhat (2002) also point out that an advantage of the commodity-based approach is recognising the sensitivity of commodity flows to economic and transport system influences, and it explicitly recognises commodity flows as the underlying determinant of freight traffic. However, commodity-based models do not estimate short-distance service vehicle trips, which may dominate intra-regional and urban freight vehicle movements and the estimation of empty trips also presents some methodological challenges. Nevertheless, this approach is well suited for the modelling objective of commodity flow analysis if sufficient commodity flow data is available. Commodity-based methods can, however, suffer from data limitations, including data that is missing for some industries and commodities (Giamo, 2006; Sivakumar & Bhat, 2002). As most commodity flow surveys do not have universal coverage, this approach is often combined with matrix estimation techniques to account for the missing movements.

There are a number of applications of gravity models to commodity-based approaches (see Table 2.5), although some researchers have applied different approaches. Sivakumar and Bhat (2002) for example, employed a fractional split distribution model.

Table 2.5:   Examples of commodity-based approaches

Source	Comment
Black (1999)	The Indiana model was based on a 1993 CFS database. Rail and truck were included. Trip generation: linear regressions (employment and population as independent variables) formed the basis for forecasting commodity productions and attractions. Distribution: constrained gravity models. Mode split: historical splits. Assignment: all-or-nothing.
Huang and Smith (1999)	Truck mode. No generation. 1993 CFS data provided the basis for a full O–D truck-trip table. External trips were

Source	Comment
	assigned with two methods: boundary balancing and global shortest path. The gravity model was calibrated for each trip type and for the allocation of external trips to external stations. Friction factor curves were developed and tested. Trip tables were merged and assigned to the network and link volumes were compared to actual truck volumes.
Sorratini, Smith (2000)	1993 CFS data and Reebie TRANSEARCH database were used to create commodity trip tables. A gravity model was used to distribute internal and I–E truck trips. A Fratar model was used to distribute E–E trips. Trip length frequency distributions developed in a previous study were used for calibrating the gravity model. The all-or-nothing assignment technique was used after merging all four trips types.
Sivakumar and Bhat (2002)	The 1996 Reebie TRANSEARCH database (primary data source) was used, as well as county business pattern database, US Census population projections, REIS database and TransCAD-related data. Consumption levels determined at each zone in a commodity generation step (using linear regression or spatial I–O models), and then a fractional split distribution model (multinomial logit form) was applied to estimate the fraction of consumption at the destination zone that originated at each production zone. Mode assignment was achieved via a composite travel impedance function.
Jones and Sharma (2003)	Data from 1993 CFS data, census of agriculture, Nebraska Databook, and the 1992 U.S. Economic Census was used to develop annual tonnages of commodities produced and hauled by trucks. These production estimates were disaggregated to county and traffic analysis zone levels using employment and population data. Freight attractions were estimated using an I–O approach and the IMPLAN software that uses a 1992 database. Methods of distribution and assignment were not discussed in the paper.
Aurecon/IMIS (2006)	Developed the Melbourne Freight Movement Model in 2005–06. The model primarily focuses on heavy vehicles for freight movement and estimated current and future freight demands by industry classes.

2.5.   Inter-agent Interaction Modelling Approach

The inter-agent interaction approach depicts the economic interactions stimulating freight outcomes, which are expressed as integrated models of varying degrees of sophistication. The general premise underlying these models is that transport demand is derived from trade activities that people or businesses need, or wish, to perform. Freight movements are a consequence of economic exchange and freight demand is a result of commodity movements from producers to consumers (Alstadt & Coughlin, 2012; Sivakumar & Bhat, 2002). As Sundberg (2009) points out, economic activities that take place at different locations and interact through trade typically incur transport costs transport is a derived demand, 'Transport is not necessarily a good in itself but may be a by-product of the need to move people and goods in space' (Sundberg, 2009). Alstadt and Coughlin (2012) argue for a macro perspective in freight forecasting and note, 'Reasonable demand projections for a single piece of freight infrastructure

(at the micro level) must acknowledge changing patterns of economic exchange supply and demand at the macro level'. Integrated economic activity models take this macro perspective into account by focusing on the spatial patterns of economic activity that drive freight outcomes.

The economic concepts that underpin the various spatial approaches to transport modelling are described by van den Bergh, Nijkamp, and Rietveld (2004). A spatial price equilibrium (SPE) occurs when space is considered from a discrete, multi-regional perspective and when transport costs are fixed, or exogenous (not influenced by economic variables), and demand and supply functions for a single product are given. This SPE concept can be extended to multiple products when independent transport of each good is assumed and products interact via the transport system (e.g. combined transport, congestion, density effects). Including transport as an economic, profit-making sectors (with endogenous costs and prices) results in competitive spatial equilibrium, which is a general spatial equilibrium (GSE) approach. According to van den Bergh et al. (2004) there are three main directions for spatial approaches to deal with transport issues in an economic context:

1. Descriptive models of commodity flows can be used to derive transport and simultaneous economic effects. However, transport parameters are exogenous (i.e., not influenced by economic variables) so estimating economic and transport effects may be biased.
2. Fixed transport parameters can be used to search for optimal transport service levels and distribution (e.g., over a network or multi-regional system). Optimality is defined for least cost or maximum social welfare (consumer and producer surplus). These are network equilibrium models or partial GSE models.
3. Use approaches that allow for endogenous transport costs and prices, based on assumptions of individual, rational behaviour and optimisation of welfare, utility, profit or cost. This is in thesea GSE approach where the values of all price variables are determined sequentially or simultaneously.

According to Sivakumar and Bhat (2002), SPE models represent the spatial distribution of producers and consumers by location-specific supply and demand functions. SPE models also assume that shippers determine the commodity flow between regions based on costs. However, the interaction between shippers and carriers is not considered. In contrast, network equilibrium models focus on shipper–carrier interactions. Network equilibrium models use freight flows by O–D pairs and by carrier, based on the concept of cost-minimising behaviour by shippers. When the carrier-specific freight flows by O–D pair are determined, each carrier decides on the routing of freight flows based on a traditional trip assignment model (Sivakumar & Bhat, 2002). These models can use either individual-level shipper and carrier data or aggregated shipper and carrier data. Harker (1988) noted that cost minimisation can be modelled in a non-cooperative (user equilibrium) or cooperative (system equilibrium) way. The non-cooperative approach assumes that agents try to minimise their own travel costs (non-cooperatively). The co-operative approach assumes that one agent controls the entire network and route flows to minimise system cost Harker (1988) presented a model where each origin–destination pair can be either non-cooperative or cooperative.

Tavasszy (2006) observed that research has been undertaken on multimodal network assignment for freight in Europe. Several countries such as the Netherlands, the UK, Finland, Sweden and Belgium have developed hyper-network approaches for freight network modelling. These network assignment models consider mode and route choice simultaneously, with most of the models using aggregate data. Other models, however, treat mode and route choice separately. Work has been carried out to identify the determinants of mode choice in several countries (see Danielis & Marcucci, 2007; Danielis, Marcucci, & Rotaris, 2005; de Jong & Ben-

Akiva, 2007; Shinghal & Fowkes, 2002). Shinghal and Fowkes (2002) conducted a survey to examine determinants of mode choice for freight services in India, comparing existing road services, new road services, intermodal container services rail services. Attributes considered in this study were cost, time, service reliability and service frequency. Logistics choice elements have also been considered by other researchers. For example, Tavasszy, Smeenk, and Ruijgrok (1998) developed the Strategic Model for Integrated Logistic Evaluations) to describe logistics chains and forecast freight flows in the Netherlands. Examples of various network equilibrium models are shown in Table 2.6.

Table 32.6:   Examples of network equilibrium models

Source	Comment
Guélat, Florian, and Crainic (1990)	A multimode, multiproduct network assignment model for strategic planning of freight flows at the national or regional level. Demand data was obtained from known flow data for a base year or from O–D matrices. Data for mode choice and vehicle characteristics exogenous for each product. The network optimisation model was used to simulate network flows as a non-linear, multi-mode, multi-product assignment that minimises the total generalised system cost. The model assumed that the most efficient use of transport infrastructure is to transport freight at least total cost.
SMILE (Tavasszy et al., 1998)	The model comprises a relational database containing data on: structural elements, topological, physical and logistical characteristics of 542 types of products, sorted into 50 logistical families; networks of road, rail, inland waterways, air, pipelines and sea; around 77 regions in the world (40 in the Netherlands); variables about relationships; sectoral and spatial exchanges (production functions and O–D tables); and parameters of logistics choice functions. A survey on product characteristics was also undertaken to support the model with real-life data. Production–consumption flows were determined by the economy module. The spatial distribution of flows between locations was calculated. Distribution chains were then described by a logistic choice model. For each O–D pair, optimal locations were determined for possible distribution centres, given three possible channel types. Conditional on these locations, flows were assigned to the alternative channel types, based on total logistic costs.
Beuthe, Jourquin, Geerts, and Ha (2001)	The model comprises a multi-modal geographic information system network using O–D matrices to develop a model that minimised the generalised cost of transport tasks, and assigned traffic flows to different modes and routes. The model only requires required aggregate matrices of origins and destinations plus detailed cost information on transport operations. Direct and cross-elasticity estimates of demand for three modes (rail, road and inland waterways) were derived from aggregate O–D matrices for 10 different categories of goods, plus detailed cost information on transport operations. Computation of network elasticities was not based on data analysis of actual modal choices and transport costs. A calibrated reference scenario was developed, enabling the application off simulations with different cost parameters of modal substitution and generation of direct and cross arc-elasticities for cost variations.

2.6.   Integrated Economic Activity Models

Integrated economic activity models, as shown in Figure 2.2, incorporate the same four components as the four-step commodity model. The main difference, however, is the use of

explicit econometric and land-use models that feed commodity flows into the transport models. Thus base-year commodity flows are used to estimate these economic models rather than as an exogenous input (Alstadt & Coughlin, 2012).
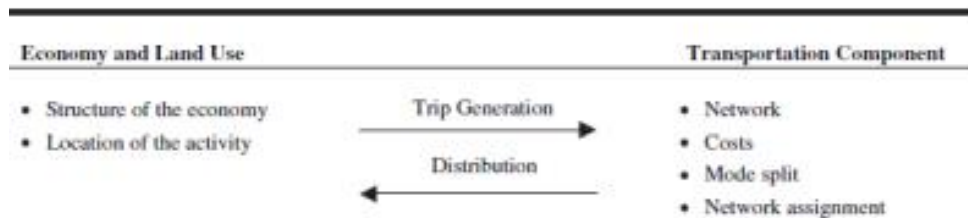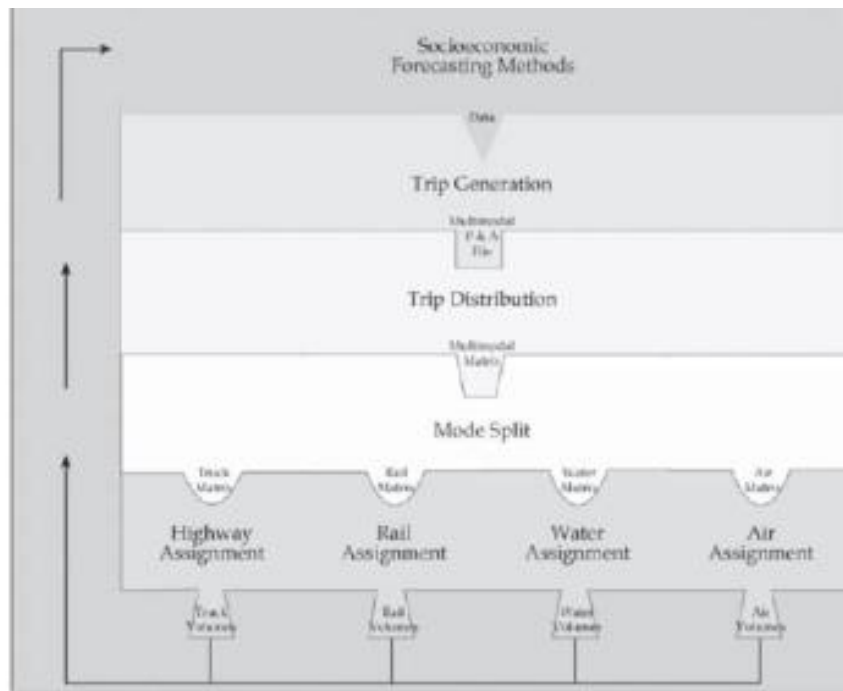
Figure 2.2:   The integrated economic activity model
Source: NCHRP (2008)

This approach is the freight equivalent of integrated land-use and transport models used in urban passenger travel. Integrated economic activity models require special data the availability of land and about the rules governing the development and location of certain industries. This information is often unavailable (NCHRP, 2008). However, there are a number of economic activity models being applied (see Table 2.7).

Table .7:   Examples of integrated economic-activity approaches

Source	Comment
The Oregon Economic Activity Model Case Study (see also Hunt et al., 2001)	In contrast to four-step commodity models, zonal employment or economic activity is not directly supplied to the model, but is created by applying an economic and land-use model. The Oregon model contains seven separate, but connected, modules that used a mix of aggregate and disaggregate approaches.
The Cross-Cascades	The modelling approach was a spatial I–O model. It distributed

Economic Activity Model Case Study (2001)	household and economic activity across zones, and used links and nodes of a transport network to connect the zones and model the transport system to calculate transport flows on the network. The location of household and economic activities are the land use component of the model.

2.7. Proprietary Systems

A number of commercially available systems can be used for freight modelling and forecasting. CRC Rail has used TransCAD and FreightSim for previous studies.

2.7.1. TransCAD by Caliper Corporation

TransCAD is transport planning software developed by Caliper Corporation. TransCAD is based on a Geographic Information System (GIS). Since the 1990s, transport analysis (GIS-T) owing to its capabilities such as visual representations of spatial data, integration of geographic data from diverse sources and ability to incorporate location factors in analysis (Sutton, 2005).

TransCAD was among the first commercially available GIS-T, designed specifically to store, display, manage, and analyse transport data. The early versions of TransCAD were generally considered to be useful and, although a basic knowledge of GIS was considered helpful, it is usually described as being 'user friendly' (Morrow-Jones et al., 1992; Waerden & Timmermans, 1996). However the user manuals lacked full descriptions of terms and did not adequately describe intermediate procedural steps (Morrow-Jones et al., 1992; Waerden & Timmermans, 1996). There was also some criticism about the database builder (Morrow-Jones et al., 1992).

TransCAD does have useful analytical and modelling capabilities (Morrow-Jones et al., 1992; Waerden & Timmermans, 1996), particularly for gravity models or location-allocation analyses (Morrow-Jones et al., 1992). The open architecture and capacity to include self-made procedures is useful (Waerden & Timmermans, 1996). However, while Waerden and Timmermans (1996) felt some improvements to modelling were needed to overcome limitations, especially for fitting distribution functions, for generating random numbers and for estimating and evaluating the multinomial logit model. TransCAD is also limited to single purpose trips.

Later versions of TransCAD include significant enhancements, but the general functionality is essentially the same. The GIS engine in TransCAD has special extensions for transport, including tools for mapping, visualisation and analysis. These features integrate with transport planning and travel demand models that predict changes in travel patterns and transport system usage in response to changes in regional development, demographics, and transport supply (Caliper Corporation, 2012). The transport modules include tools for network analysis, transport planning and travel demand modelling, transit analysis, vehicle routing and logistics, territory management, and site location modelling (Caliper Corporation, 2012). The transport planning modules comprise:

- trip generation models to estimate the number of trips, by purpose, originating in each zone of a study area

- trip attraction models to predict the number of trips attracted to each zone or to a particular land use
- trip balancing methods, so that the number of attractions equals the number of productions
- trip distribution models to predict the spatial pattern of trips or flows between origins and destinations
- mode split models to analyse and predict the choices that individuals or groups make in selecting the transport modes for particular types of trips
- P–A to O-D and time-of-day tools for converting production and attraction to origins and destinations, decomposing a 24-hour trip table matrix into hourly trip tables, converting person trips to vehicle trips, and applying peak-hour factors
- traffic assignment models to estimate network traffic flows and analyse congestion points, including variants for modelling transit and modelling intercity passenger and freight traffic by rail, road, air, and barge; there is also a master, multimodal equilibrium traffic assignment procedure that simultaneously assigns cars, trucks, and buses to the road network, with multiple user classes for vehicles
- advanced highway assignment procedures to enable generalised-cost traffic assignment, high occupancy vehicle assignment, multimodal vehicle assignment, multiple user class traffic assignment, combined trip distribution/assignment, and assignment with volume-dependent turning delays and signal optimisation (Caliper Corporation, 2012).

There are many examples of using GIS-T systems in research and practical applications. Some examples of modelling applications using TransCAD are described in the following section.

Examples of TransCAD applications

Kockelman and Krishnamurthy (2004) modelled travel demand in Austin, Texas using TransCAD. Their model incorporated nested behavioural models in travel choice alternatives, and produced welfare measures recognising all aspects. In incorporating congestion cost impacts for a particular scenario, they modified the link performance functions in TransCAD to appear as marginal cost functions. The four-step model was used to estimate the O–D matrix. This O–D matrix was assigned to the network under a base scenario, with no pricing and all performance functions taken to be the typical average cost curves.

Youngblood, Anderson, and Seetharam (2005) described a prototype simulation model of freight movements developed for Mississippi (see Tan, Bowden, & Zhang, 2004). This model used the US Commodity Flow Survey data, cargo density database and US Vehicle Inventory and Use Survey data. TransCAD was used to model change of modes at terminals, and evaluate the importance of different modes and the routes. The traditional four-step process was used and a secondary program was developed for TransCAD output and to animate the freight flow movements.

Juri and Kockelman (2006) used TransCAD to evaluate the Trans-Texas Corridor Proposal by applying a random utility-based multi-regional input–output (RUBMRIO) model. The RUBMRIO model is derived from input–output type productive dependencies, and uses logit models of input origin and mode choice. The RUBMRIO

model's trade equilibration module relies on an iterative algorithm for trade flows among zones and production within zones (254 zones and 21 economic sectors). It applies random utility theory for input purchase decisions. The RUBMRIO model also incorporates two key factors of production: land and labour. Market equilibration modules for land and labour are incorporated in addition to an internal trip generation and equilibration module. The model was driven by final demands, encompassing foreign export demands from 18 foreign export ports, and domestic demands in the US using the 1997 US Commodity Flow Survey data. To consider the impacts of road congestion on trade patterns, an iterative feedback loop was performed with TransCAD's network user equilibrium commands after each wage or trade equilibration cycle. This feedback loop relied on 'distance updating factors' to increase the shortest path distances between zones to reflect congestion levels on travel times.

Akgün, Byrne, Lynn, and Keskin (2007) used TransCAD to implement their genetically optimised O–D estimation (GOODE) model, presented in a case study of commodity movements in Ontario. They proposed an approach, based on genetic algorithms, to estimate a regional freight O–D matrix using different data sources. The GOODE model takes advantage of the genetic algorithm's (GA) to search globally for the O–D matrix that, when assigned to the transport network, gives the minimum deviation between the assigned and observed link flows. The GOODE-commodity model, an extension of the GOODE model, estimates the freight O–D matrix by linking GOODE with a trip-generation model based on I–O data. The GOODE model and its extension bring together national I–O data, truck survey data, a global searching method, and a GIS platform (TransCAD) for data manipulation.

2.7.2. FreightSim by BITRE

FreightSim was developed jointly by BITRE and FDF Pty Ltd (FDF) under the auspices of Austroads (BITRE, 2009; BTRE, 2006a). FreightSim projects inter-regional O–D freight movements across six transport modes — road, rail, sea, air, pipeline and conveyer — and enables implications of alternative economic development scenarios to be analysed. The model comprises 132 separate regions — 123 statistical subdivisions, eight capital city statistical divisions and one region covering the rest of the world. Sixteen commodity classes are also included in the model — 15 bulk commodity groups and one non-bulk group (BITRE, 2009; BTRE, 2006a).

FreightSim models growth in freight flows mainly as a function of growth in production, imports and consumption of commodities (Ernst & Young, ACIL Tasman, & Hyder Consulting, 2006). Required inputs include base year estimates of production, consumption and imports for each commodity class in each of the 132 regions. The base year freight transport movements, by transport mode, between each region pair are also required (BITRE, 2009).

Consumption is mainly driven by economic and population growth and can be specified as exogenous or endogenous to the model (Ernst & Young et al., 2006). With the exception of the production of bulk commodities, growth in production is always specified as exogenous. Production of non-bulk commodities can be endogenously or exogenously determined, as can imports. Where the growth in these variables is specified as exogenous, an externally derived set of projections is fed into the model; where the variables are described as endogenous, the model applies growth rates to the initial starting data. These growth rates are derived by regionally weighted gross domestic product (GDP) growth, adjusted by an elasticity of response of the variable to GDP growth.

FreightSim employs a 'mass-balance' equilibrating process to project future interregional freight movements for each commodity classes: total annual production plus regional imports (inflows) for each commodity class must equal the sum of total annual consumption and regional exports (outflows) for each freight region (BITRE, 2009, p. 31). FreightSim projects future consumption and imports for each commodity and each region based on the projected growth in output (income) in each region — the product of projected growth in national per capita GDP and regional population. These projected freight movements are computed as the level of freight transport necessary to transport commodities from regions where there is net excess supply to regions where there is net excess demand (BITRE, 2009, p. 32). The model iterates until all excess consumption demands are satisfied. Any remaining excess supply of a commodity is transported to the nearest suitable port for export (BITRE, 2009).

Mode-share assignment is based on competitiveness indexes set using some simple rules of about future trends in mode shares for each commodity type. These indexes are independent of distance for bulk freight, but they vary by distance for non-bulk freight. For bulk freight projections, modal assignment is based on national historical trends in freight transport mode share by commodity. Logistic substitution relationships are used to project trends in freight transport mode share. Mode share competitiveness indexes are applied for bulk freight movements, by commodity type (BITRE, 2009).

For non-bulk commodity projections, freight movements are based on a gravity model where growth in inter-regional, non-bulk freight is assumed to be proportional to growth in regional populations, national average per capita, GDP growth and changes in real average freight rates (BITRE, 2009). The projected freight task is then assigned to different modes based on observed historical trends in non-bulk interstate mode shares; however, the assumed mode share competitiveness indices also vary by distance, reflecting the historical propensity for future mode shift by distance (BITRE, 2009). For O–D pairs less than 1500 kilometres apart, road freight is assumed to increase in mode share, relative to rail and coastal shipping, where they are viable alternative modes. On longer distance routes, rail is assumed to capture mode share from road and, to a lesser extent, coastal shipping (BTRE, 2006a). These assumptions reflect contestability parameters. The application of these parameters has important implications for using FreightSim where contestability issues are of central concern.

BTRE (2006a) points out that an advantage of FreightSim is its ability to project growth in Australia-wide, long-distance freight movements between major population centres. However, this breadth of coverage requires some abstraction for small-area, local-level influences that may affect growth in local traffic. In these instances, FreightSim projections can be augmented with more detailed local-level information, if it is available (BTRE, 2006a).

FreightSim does have is also limited in its ability to assess modal contestability due to its treatment of mode choice. The mode share competitiveness index is mostly derived from past patterns of mode use. It does not explicitly treat factors that may alter the attractiveness of alternative modes, such as changes in service cost, time or reliability as a result of infrastructure investments. These types of influencing factors can only be handled implicitly through adjustments to the mode share competitiveness index value (BITRE, 2009).

Some examples of modelling applications using FreightSim are described in the following section.

FreightSim Application Examples

Australian Government 2006

The Australian Government made used FreightSim to formulate demand projections for Auslink non-urban corridors. The base-year production, consumption and inter-regional transport flows were based on FDF's *FreightInfo 1999* national database of Australian freight movements. However, the *FreightInfo 1999* data appeared to significantly under-estimate the total inter-capital, non-bulk road freight task. This data was augmented with data from the Australian Bureau of Statistics' (ABS) Freight Movement Survey (FMS) (ABS, 2002) for non-bulk road freight movement estimates between capital city statistical divisions and major provincial urban centres.

For mode share, the projections abstracted from planned future infrastructure investment in road and rail. However, there was no attempt to explicitly account for the effects of future infrastructure changes. The implication of this decision was that the projections were based on assumed future continuation of the relative performance levels provided by current infrastructure (BTRE, 2006a).

Australian Government 2009

The Australian Government's Department of Infrastructure, Transport, Regional Development and Local Government used FreightSim to derive long-term passenger and freight vehicle traffic projections for the intercity corridors of the National Land Transport Network (NLTN) between 2005 and 2030.

The base year production, consumption, imports and inter-regional freight movement estimates were based on FDF's *FreightInfo 1999*, augmented by road freight data from the 2001 FMS (ABS, 2002) and the 1998–99 ASF. BITRE had planned to use the FreightInfo 2004 data for these projections, but the data was regarded as insufficiently accurate (BITRE, 2009). FDF's *FreightInfo 2003–04* could not be satisfactorily reconciled with other transport data, so *FreightInfo 1988–99* was used, together with data from the ABS's *2000–01 FMS* and BITRE's *1998–99 Australian Sea Freight Statistics*. For the NLTN corridor freight vehicle traffic projections, the 1998–99 base year freight task was projected forward to 2005. The 2005 projections were used as the basis for matching on-road heavy vehicle traffic data. BITRE also attempted to corroborate the projected 2005 data against other independent evidence on freight movements, especially road freight movements, by comparing the projected road freight data against state/territory supplied by the CULWAY/WIM site data).

For mode assignment, BITRE factored in mode share competitiveness indices to reflect implicit assumptions about the relative mode shares of rail and road (BITRE, 2009). In particular, there had been considerably greater investment in road network infrastructure relative to rail infrastructure, providing greater scope for improvement in intercity rail freight performance, particularly on longer (>1500km) routes. The projections assumed that rail's share would increase relative to other modes, particularly road, on these longer routes (BITRE, 2009, pp. 34-35).

Ernst & Young 2006

Ernst & Young et al. (2006) used FreightSim for the North–South Rail Corridor Study commissioned by the Department of Transport and Regional Services. They noted

FreightSim was, 'the best tool of its type currently available" (Ernst & Young et al., 2006). It was also noted that it was "recognised internationally as an industry leading model'. They considered, 'the framework of FreightSim and the FreightInfo database to be robust, and a reasonable approach to forecasting future freight movements' (Ernst & Young et al., 2006).

2.8.   Spatial Computable General Equilibrium Modelling

The recent use of SCGE modelling provides a new tool to consistently model trade and production and consumption within an economic system (Sundberg, 2009; Tavasszy, 2006). Sundberg (2009) states that SCGE modelling takes account of inter-sectoral and inter-regional relationships, making it a suitable tool for obtaining economy-wide, direct and indirect effects of transport policies. Consequently, there has been growing interest in using SCGE models to assess the economic and welfare effects of infrastructure investments and transport-related policies (Sundberg, 2009; Tavasszy, 2006; Tavasszy, Thissen, & Oosterhaven, 2011). For example, one of the first SCGE models in Europe was the CG Europe model, developed by Bröcker, Kancs, Schürmann, and Wegener (2001) to quantify regional welfare effects of transport-related and financial–economic policies (also see Bröcker, Korzhenevych, & Schürmann, 2010).

The application of SCGE for freight modelling has been recognised. For example, Tavasszy (2006) argues it would be a 'logical step' to connect an SCGE model to a model of the freight transport system by replacing conventional I–O and gravity models. Using an SCGE would offer theoretical consistency within freight modelling, while enhancing the assessment of indirect welfare effects. Others have also noted the benefits of an SCGE approach for freight modelling (for example, see de Jong & Ben-Akiva, 2007; Ivanova, Vold, & Jean-Hansen, 2003). Ivanova et al., (2003) state that the SCGE approach is, 'well suited for forecasting of interurban freight transport flows since it captures the geographical dimension of consumption and production activities'. They also note that, by organising the economy into a number of regions that act as nodes in a spatial network, SCGE models allow for explicit consideration of inter-regional transport costs (Ivanova et al., 2003, p. 3). However, Tavasszy et al., (2011) point out that using SCGE models for transport poses some challenges, including linking SCGE with other transport models; modelling the effect of transport costs on sectoral production; interpreting conventional, micro-level specification of product variety in aggregate applications; and addressing the problem of irrational agglomeration effects in economic activities. Table 2.8 provides examples of where SCGE models have been applied.

Table 3.8.   Examples of the use of Spatial Computable General Equilibrium (SCGE) models

Source	Comment
de Jong and Ben-Akiva (2007)	A model focusing on the integration of a logistics component within a broader framework. This model included the determination of shipment size and the use of consolidation and distribution centres, within a behavioural framework, which could be estimated on disaggregate data and applied in micro-simulation. For production–wholesale–consumption (PWC) flows, matrices were generated by spatial I-O models or SCGE models, which allowed for multiple legs, including changes of mode, and consolidation or de-consolidation of shipments. Network assignment: PWC flows were input into the logistics module, after disaggregation to firm-to-firm (sender-to-receiver) flows. The outputs of the logistics model consisted of O–D vehicle flows, which were used in aggregate network assignment. Logistics module: incorporated frequency and shipment size (inventory decisions endogenous); number of legs in the transport chain (direct transport, two legs, etc.); use and location of consolidation and

Source	Comment
	distribution centres; road, rail, sea, and air modes for each leg, with choice of vehicle or vessel type and loading unit (unitised or not).
PINGO Ivanova et al. (2003) Also see Hovi and Vold (2003)	PINGO is an SCGE model for Norway to forecast freight transport flows between Norwegian counties and for policy analysis such as welfare–benefit analysis of infrastructure investments, transport policy and investment analysis. The model had a detailed representation of transport activities and had an explicit link to the national real freight network model (NEMO). NEMO is a model for transport chain and route choice. It provides data on transport flows between the 19 regions of Norway, calibrated for a base year (1999). It includes 11 commodity groups. For each commodity group, NEMO calculates the cheapest transport chains between zones consisting of one or a combination of three modes (truck, train and boat). PINGO and NEMO comprise a united modelling framework. Any changes in transport infrastructure and other factors influencing transport costs are converted into the changes in transport costs using NEMO, providing exogenous input to PINGO allowing further economic and welfare analysis and derivation of transport flows between the counties. The growth rates of transport flows between counties provided by PINGO are used as input to NEMO for further analysis of changes in freight transport flows on the particular links of the real network, which allowed for calculating the corresponding figures of tonne kilometres or environmental costs etc. at different levels of aggregation. PINGO includes 10 commodity groups, nine production sectors, 10 service sectors and 11 investment sectors. The choice of commodity groups were predetermined by the need to coordinate PINGO with NEMO.

3. Choice of Model for Freight Contestability

Determining methods to use to examine the contestability of non-bulk freight flows for rail and road in Australia has two dimensions:

1. method selection — determining a suitable modelling approach
2. corridor selection — determining suitable sites for testing the validity of models.

3.1. Model Selection

There is a variety of methodological approaches and an array of estimation techniques that can be used for freight modelling. The approaches are so diverse that even grouping or classifying models is challenging. For example, four-step modelling can use various methods of O–D matrix estimation to account for missing data, and can use different assumptions and techniques for mode allocation. Integrated economic activity models can use I–O techniques or SCGE techniques base-year flows and each have unique characteristics. Models can also use either aggregated or disaggregated data and can either address or ignore agent behavioural factors, transport system investments, or other factors that influence mode choice. The different methods all have strengths and weaknesses that are suited to different aspects of the freight modelling task. This diversity highlights the need to consider the advantages and limitations of any modelling approach given the goals and constraints of the particular modelling task.

In selecting a modelling approach, modellers can choose a pre-existing, commercial modelling system, with or without adaptation, or they can develop a new, customised model. According to the DOT (2003), choosing a model depends on a number of potentially conflicting factors:

- policy and analytical needs
- data availability
- need to conduct new surveys
- timescale for model development

the required accuracy and robustness of results and recommendations. Model selection can be distilled into balancing the advantages and disadvantages of various approaches within the resource constraints. For instance, aggregation can be convenient due to data limitations; however, aggregation masks individual differences and outcomes may vary greatly from predicted values. Yet a disaggregated approach may require investments to obtain missing data that are beyond the project budget. Given this perspective, the following sections draw out some of the key factors that impact on the selection of a suitable modelling approach for freight contestability.

3.2. Narrowing the Field: Weighing Up the Different Approaches

3.2.1. Four-Step Models

Four-step models have intuitive appeal and, subject to their limitations, offer a useful and well-used approach. As Combes and Leurent (2009) observe, the segmentation of decisions impacting traffic is suited to modelling and generally allows for a clarification of the hierarchical relations between decision levels.

However, conceptual and methodological limitations of four-step models need to be recognised. Four-step models require substantial data input to derive commodity flows and estimation techniques frequently need to be used. Gravity models are aggregate in nature and include general assumptions for determining the influence of friction factors. The mode choice step often uses crude assumptions that are mostly based on

historical, collective (aggregate) patterns of behaviour (e.g., FreightSim and TransCAD). Aggregation, while convenient and sometimes necessary, does mask individual differences and has implications for fully understanding behavioural influences. Winston (1981) argued that aggregate approaches obscure observed differences in shipper or receiver behaviour, so can fail to determine if there actually is contestability between modes.

The applicability of vehicle-based models to multiple freight transport modes is questionable because the choice process focuses on the trip itself, making it difficult to identify and determine economic and behavioural mechanisms of freight demand (Holguin-Veras et al. 2001). Vehicle-based modelling lacks a mode choice step, making it an inappropriate approach for freight contestability modelling. Commodity-based modelling overcomes this conceptual limitation by explicitly recognising commodity flows as the underlying determinant of freight traffic. This approach also enables commodity-based models to capture the economic mechanisms that impact freight movements in a limited way; their capacity to capture economic mechanisms is more limited than integrated economic activity models.

Four-step models originated as passenger transport models; however, there are fundamental differences between passenger and freight movements. These differences create methodological challenges for the models, with the underlying assumptions influencing their application within the freight context. Important differences stem from the relative heterogeneity of freight and of the shippers determining freight transport (Combes & Leurent, 2009). One of the main differences is the unit of analysis (people versus freight) and the nature of the decision-making agents (passengers versus shippers). Challenges also arise in trying to incorporating behavioural and other factors that impact logistic decisions and mode choices. Combes and Leurent (2009) point out, 'The freight transport supply consists of the supply by carriers, a group of a large number of heterogeneous agents, of transport options with very different characteristics'. Because most four-step models rely on aggregate data, relevant individual differences can be masked. For example, aggregation can mask how freight characteristics such as size, shape and bulk impact freight movements or how behavioural factors, such as the decision criteria of shippers impact mode choices.

Also challenging for four-step models is the incorporation of dynamic influences of changes to transport system parameters, such as improved efficiency from infrastructure investments) , and how this affects shippers' mode preferences. Four-step approaches can also fail to recognise the impact of dynamic influences on mode splits. In FreightSim, for example, mode allocation is aggregate and historically grounded, relying on past transport patterns for future mode shares. This assumption largely ignores factors such as infrastructure development or service changes that might be 'game changers'.

Overall, four-step models are a good starting point and, if sufficient data is available, they offer a sound approach. Within four-step approaches, commodity-based modelling is the only suitable option for contestability modelling.

3.2.2.   Integrated Economic Activity Models

Integrated economic activity models encompass a wide variety of techniques. All integrated economic models are generally conceptually appealing because they explicitly recognise that transport demand derives from economic activities distributed across space and required interaction between economic agents. Yet integrated

economic activity models are generally more complex, offer lesser intuitive appeal, and may be more inflexible compared to four-step approaches.

One of the advantages of integrated economic activity models is their capacity to model the economic effects of transport policies, or changes in transport parameters. For example, Hansen (2010) states that SCGE models encompass the entire economy, so they are suited to analysing the wider economic effects of transport investments. They also take account of the link between the transport sector and transport-using sectors, acknowledging that an exogenous change in one sector may produce changes throughout the economy. Integrated economic activity models approaches also generally overcome data requirements by endogenously generating data inputs with econometric and land-use models feeding base-year data into the modes. However, integrated economic activity models require special data concerning about the availability of land and about the rules governing the development and location of certain industries. This information is often unavailable (NCHRP, 2008).

Integrated economic activity models typically use I–O techniques or, more recently, SCGE techniques. SCGE modelling has some advantages over I-O techniques. For example, reduced transport costs due to infrastructure investments tend to stimulate actors in the economy to take advantage of the cost reduction in production and consumption (Sundberg 2009). Brocker (1998) provides a useful explanation of the methodological differences between I–O and SCGE modelling. Multi-regional I–O analysis is a standard approach used in empirical spatial economics. One of the strengths of I–O analysis is its ability to take account of inter-regional, inter-industry interdependencies. However, the disadvantages of I–O analysis include:

- it can be inflexible because of a fixed-coefficients assumption, which is inconvenient for trade coefficients
- it can fail to sufficiently account for income–expenditure interdependencies
- it is often one-sided demand driven, so that effects coming from the supply side, such as cost and capacity variations, cannot be modelled appropriately (Brocker, 1998, p. 367).

SCGE models are methodologically superior because they maintain all the modelling capacities of I-–O techniques, without these limitations (Brocker, 1998). According to Brocker (1998), 'If we are content on making plausible assumptions about things which we cannot observe for acceptable costs, and if we are satisfied by calibration instead of econometric estimation, SCGE can be cheap and still highly satisfying from a methodological point of view'.

This point highlights the fundamental issue in model selection — the choices between different approaches involves trade-offs. Selecting any approach will pose challenges. While these challenges can be overcome, limitations need to be recognised first, and the resource implications of addressing particular challenges need to be weighed against the practical constraints of the task parameters. A brief summary of some of the advantages and disadvantages of the different models and approaches is given in Table 3.1.

Table 3.1: Brief Summary of Different Approaches

	Strengths/advantages	Weaknesses/challenges
Four step approaches	Conceptually simple and intuitive. Explicitly depict steps and hierarchical relationships in freight transport decisions.	Adaptation from passenger transport models presents challenges: modelling heterogeneity and incorporating behavioural and other factors impacting logistics decisions and mode choices (e.g., infrastructure investments, behaviour of shippers and decision factors).
Vehicle-based modelling		Truck modelling lacks mode choice component, making it entirely inappropriate for mode choice analysis or commodity flow analysis.
Commodity-based modelling	Explicit recognition of commodity flows as the underlying determinant of freight traffic. Focus on cargoes enables models to capture economic mechanisms that impact freight movements.	Frequently data is missing so estimation techniques are required to determine commodity flows (limitations of different approaches – e.g., linear regression, I–O). Gravity models for trip distribution are aggregate in nature and involve assumptions underlying friction factors. Mode choice often uses aggregate assumptions based on historical data (splits). Often fail to account for new influences such as changes in efficiency and cost due to infrastructure investments.
Integrated economic activity models approaches (various approaches)	Transport is a derived demand from economic activities distributed across space, involving interaction between economic agents. Overcome data limitations by using econometric and land use models to feed base-year data flows to models.	Models can be designed to incorporate logistics and other behavioural elements. SCGE is methodologically superior to I–O techniques. Less intuitive and relatively greater complexity of models, although methodologically robust.
Proprietary Systems Examples		
FreightSIM	Includes the strengths of an integrated economic activity model.	Limitations of I-O approach Fails to address mode choice — applies indices based on past use.

	Strengths/advantages	Weaknesses/challenges
		Crude assumptions about effects of infrastructure investments on logistic choices (e.g., relative investments in road versus rail impact efficiency and mode choice). No explicit treatment of factors impacting shippers' logistics choice or other behavioural influences.
TransCAD	A GIS-T system that offers advantages in terms of mapping features and interface. Strengths of four-step approach (as noted)	Limitations of four-step approach as noted. No treatment of behavioural factors impacting shippers' mode choice.

3.3.   The Preferred Approach

On balance, the four-step commodity-based method appears to be the most suitable for modelling contestability between road and rail for non-bulk freight. Commodity-based models are suited for representing movements across manufacturers and for characterising external trips. Commodity-based models can generate movements irrespective of mode. These movements can then be used in conjunction with other sub-models for the mode choice process. They are more easily adapted to multimodal analysis (Holguin-et al., 2002). Commodity-based models can produce weekday freight volumes on major freight flow facilities in a region and assess the annual tonnage of commodities produced or consumed by mode, by zone, and by origin and destination. Therefore, the four-step commodity based approach is suited for modelling commodity flow analysis. Although TransCAD is based on a four-step approach, it has poorly specified user manuals, and is being reworked for re-release during 2012. While TransCAD uses open architecture, it requires modification to meet the project's objectives. FreightSim is also limited for assessing mode contestability.

Developing a new, purpose-designed model is recommended. Developing a customised, four-step commodity flow framework will enable the type and amount of non-bulk freight commodities that would be contestable by rail to be identified.

3.4.   Corridor Selection

To test any model, a freight corridor with rail and highway networks needs to be selected. A suitable freight corridor must be able to satisfy the aim of the project, namely, to evaluate contestability of rail versus road for non-bulk freight. The characteristics of the chosen corridor must be considered, particularly the current dominance of road versus rail freight and the potential for significant change in mode shares. Any shift in mode share must also be able to be assessed in turn offering in terms of implications for infrastructure use, road congestion and environmental effects. For a case study rail must, at least conceptually, be able to achieve a substantial increase in non-bulk freight market share, and possibly attaining significant congestion reduction benefits for road users, as well as environmental benefits from reductions in greenhouse gas and particulate emissions. Consideration must also be given to the resources and time available for successful project implementation. The chosen corridor must not have a

complex freight environment that could overly complicate the initial modelling task. The relevant actors in the corridor must also have an interest in effecting change in practice.

The Australian rail freight market for non-bulk or intermodal freight can be broken up into several distinct corridors or segments:

East–West	Sydney–Parkes–Melbourne/Adelaide–Perth
	Operators: PN, QRN & SCT
North–South	Adelaide–Darwin
	Operators: GWA
East Coast	Melbourne–Sydney–Brisbane
	Operators: PN & QRN
Queensland	Brisbane–Townsville–Cairns
	Operators: QRN & PN
New South Wales	Regional areas–Sydney
	Operators: PN, Qube, IRA & Freightliner
Victoria	Regional areas + Southern NSW–Melbourne
	Operators: PN, SCT, Qube & El Zorro

There are also lesser traffic flows in South Australia, Western Australia and Tasmania.

Operator codes:
PN   Pacific National (Asciano),
QRN   QR National Ltd
SCT   SCT Logistics, previously Specialised Container Transport
GWA   Genesee & Wyoming Australia
Qube   Qube Logistics (previously POTA and Southern & Silverton)
IRA   Independent Railways of Australia (announced as sale to Qube Logistics approved by ACCC)
Freightliner   part of Freightliner UK
El Zorro   El Zorro Transport of Melbourne.

In the East–West and North–South corridors, rail currently performs well in terms of market share, accounting for at least 80 per cent of non-bulk freight transport. However, it does not perform well in the other areas. The New South Wales and Victorian areas have a variety of modes used to transport non-bulk freight, which poses a complexity challenge for modelling. There appears to be little interest in the Queensland corridor shifting market share between rail and road. The East Coast has the greatest concern for the contestability of freight (ARTC, 2007). Based these criteria, the East Coast Corridor has characteristics that best support the project's aims.

According to Ernst & Young et al., (2006) and the ARTC (2007), the East Coast corridor services 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 per cent of the total freight flow). Of the inter-capital city freight, an estimated 47 per cent is on the Melbourne–Sydney corridor, 32 per cent is on the Sydney–Brisbane corridor, and 21 per cent is on the Melbourne–Brisbane corridor (Figure 3.1). Rail is most competitive on the Melbourne–Brisbane corridor, with an estimated 22 per cent of market share. On the other two corridors, market shares are estimated to be 9 per cent between Melbourne and Sydney, and around 11 per cent between Sydney and Brisbane. The differences between the mode shares in different

sections of the East Coast corridor implies that there is scope for potentially gaining greater insights into factors impacting on shippers' mode choice.

The East Coast corridor is currently a problem for freight operators. The rail industry is concerned that existing intermodal freight services, especially the East Coast corridor, are under threat from the possible introduction of B-triple trucks, an outcome that the trucking industry is lobbying for on the grounds that it will improve the efficiency and sustainability of freight transport. While there is essential and welcome investment taking place in the East Coast inter-capital rail corridors, the Melbourne–Sydney and Sydney–Brisbane intermodal services are uncompetitive, compared to road. If this scenario continues, rail will inevitably have to abandon any intermodal services for haulage distances of less than 2000 kilometres. The shortfall will be taken up by road transport, with the associated increase in greenhouse gas and particulate emissions and loss of external economic benefits. This mode shift would also give rise to an increase the externalities associated with road transport, including increased traffic congestion and noise; accelerated degradation of road infrastructure (affecting all road users); and higher incidence of traffic accidents, injuries and deaths (insurance, hospitalisation and foregone tax revenue).

The corridor is well defined as part of the designated National Network.

Based on this assessment, the East Coast corridor was chosen as the test corridor for the proposed model.
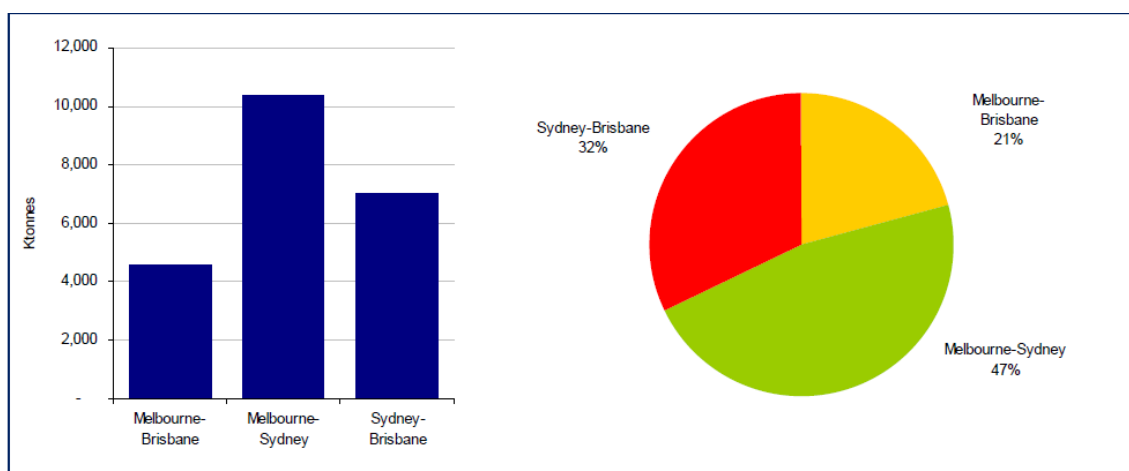

Figure 3.1: Inter-capital freight — all modes
Source: Ernst&Young 2006

4. Proposed Model for the Preferred Approach

4.1. Overview

Initially, the preferred approach for developing the East Coast Freight Model (ECFM) was to develop a four-step commodity flow analysis to assess contestability between rail and road modes for transporting non-bulk commodity freight in the East Coast corridor. The ECFM should address: the truck and train movements on the East Coast highway systems and rail networks; the shipment of commodities between regions on the East Coast; and the shipment of freight between the East Coast and the rest of Australia. The ECFM will be designed to forecast truck and train freight volumes in response to changes in freight modal characteristics such as increased truck costs or reduced rail shipment times. The ECFM will also attempt to forecast truck and train volumes in response to changes in the national economy such as growth or decline in certain industries. The ECFM will provide forecasts needed to analyse freight movement changes by changing the input variables of the model.

The input variables of the ECFM will be similar to other commodity flow models used in Australia and overseas. The basic demand variables will be population and employment. A commodity flow database will be developed to generate the model coefficients and parameters for the ECFM. The commodity flow database provides information by origin, destination, commodity, and mode of the annual shipment of tons to, from, and within the East Coast corridor. Commodity groups will serve a similar function to trip purposes. A total of eight commodity groups have been defined for the ECFM. The area covered by the ECFM includes the entire East Coast of Australia. The ECFM uses 10 internal TAZs and establishes external regional zones outside the East Coast at a sparse level.

4.2. Data Sources

The proposed study will need to use the best available public data to develop the ECFM. The following sections outline data sources that can be used to support the development of the model.

4.2.1. Freight Movements Survey

The ABS's FMS collected information about domestic freight movements from road, rail and air freight operators. Information collected by the BTE from port authorities was incorporated with the information published from the survey. FMS published information on the origin, destination, commodity type, weight and method of transport. The publication contains information for the year ending 31 March 2001. As a result of funding constrains, the survey was discontinued from 2001.

4.2.2. Weight-in-motion data

Weight-in-motion (WIM) data could potentially provide additional information about network road freight movements on monitored links (Mitchell, 2010). WIM sites capture information about heavy vehicle type (axle configuration); vehicle speed; and gross vehicle mass from which indicators of road freight activity at each site can be

derived. In Australia, state and territory government road authorities operate a relatively extensive set of WIM sites across the non-urban highway network.

4.2.3.   The Enormous Regional Model

Monash University's TERM (The Enormous Regional Model (TERM) is a 'bottom-up' CGE model of Australia. It provides a detailed representation of Australia's regions and sectors. TERM previously identified a 144-sector, 57-region database (almost corresponding to the statistical divisions used by the ABS) and it has recently been extended to represent 172 sectors in 206 statistical sub-divisions (Monash University, 2012). TERM provides an opportunity for creating a bottom-up multiregional database that treats each region of a single country as a separate economy (Monash University, 2012). The I–O coefficients derived from the TERM database at the regional level could potentially be used to develop trip attraction rates.

4.2.4.   Survey of Motor Vehicle Use

The Survey of Motor Vehicle Use (SMVU), conducted by the ABS from the year 2000, presents statistics on passenger vehicle, motor cycle, truck and bus use for characteristics such as distance travelled, tonne-kilometres and fuel consumption. The data is collected in quarterly sample surveys.

4.2.5.   Maptitude GIS Database

Caliper Corporation (a worldwide leader in GIS, transport and mapping software) has published a detailed data product named *Maptitude 2012* for Australia. It includes extensive geographic and demographic data such as highways, railways, statistical areas including population, household income and dwellings. This product also enables 3D surface visualisations.

4.2.6.   Population and Employment Data

Statistical division population and employment data can be obtained from the ABS 2006 Census data. The employment data for different commodities can be mainly obtained from relevant state government agencies (e.g., Office of Economic and Statistical Research [OESR] in Queensland).

4.3.   Model Structure

4.3.1.   Commodity Flow Survey

In the US, the US Commodity Flow Survey (CFS) is conducted every five years. The most recent (2002) survey reports commodities by classification of transportable goods code and contains both value and tonnage data for each commodity by state. This information could be used to develop conversion tables detailing value per ton by commodity. In Australia, however, detailed O–D level freight surveys like the US CFS, have been undertaken very infrequently. The last comprehensive survey of O–D road freight movements in Australia was the ABS 2000-01 Freight Movement Survey (FMS). Creating a commodity flow database will therefore present the greatest challenge in developing the proposed model. This challenge may be able to be addressed by combining data from different sources; specifically, FMS data could potentially be used

to derive the state and regional level O–D by commodity, by mode together with data from other public databases such as WIM and TERM.

4.3.2. Commodity Groups

The FMS database includes 8 eight separate classifications of commodities. The commodity groupings proposed for the ECFM are shown in Table 4.1.

Table 4.1: Proposed Commodity Groups

Group code	Commodity group name
1	Food and live animals.
2	Beverages and tobacco.
3	Crude materials, inedible (excludes fuels).
4	Mineral fuels, lubricants and related materials.
5	Chemicals and related products n.e.s.*
6	Manufactured goods.
7	Machinery and transport equipment.
8	Miscellaneous manufactured articles.

*not elsewhere specified.

4.3.3. Forecast Variables

The traditional four-step commodity flow models forecast trips based on zonal socioeconomic data such as population and employment. Population and more detailed statistical division employment groupings will serve a similar function in the ECFM.

4.3.4. Zone Structure

The ABS FMS (2001) has identified 57 regions (mainly statistical divisions by ABS definition). Aggregation will be required to enhance data manageability. The ECFM will aggregate the ABS's 57 regions into 10 geographical regions as shown in Table 4.2.

Table 4.2: Proposed Zone Structure

No	Regions specified for the East Coast Freight Model
1	Brisbane
2	Northern Queensland
3	Southern Queensland
4	Sydney
5	Northern New South Wales
6	Central New South Wales
7	Southern New South Wales
8	Northern Victoria
9	Melbourne
10	Western Australia and South Australia

4.3.5.   Specific Freight Transport Networks

The ECFM will use the currently defined National Network land transport corridors on the East Coast. Figure 4.1 illustrates the defined National Network road and rail corridor between Melbourne, Sydney and Brisbane.

The road corridor links for the Melbourne–Sydney section comprise:
- the Hume Highway and the Hume Freeway from its connection with the South Western Motorway at Prestons in New South Wales to its junction with the Western Ring Road at Thomastown in Victoria.

For the Sydney–Brisbane section, the National Network road corridors include:
- the Pacific Highway between Newcastle and Brisbane
- the New England Highway to the Cunningham Highway
- the Cunningham Highway from the New England Highway to the Ipswich Motorway;
- the F3 Freeway from Newcastle to Sydney.

Finally, for the Melbourne- Brisbane section, the National Network road corridors include:
- the Goulburn Valley Highway from its junction with the Hume Freeway at Seymour to Tocumwal
- the Newell Highway and the Cunningham Highway to its intersection with the Leichhardt Highway;
- then the Leichhardt Highway between the Cunningham Highway and the Gore Highway
- the Gore Highway to its intersection with the Warrego Highway
- the Warrego Highway to its intersection with the Ipswich Motorway at Brisbane.

The rail corridors are also depicted in Figure 4.1. The rail link between Sydney and Melbourne includes Moss Vale to Port Kembla. The rail corridor between Sydney and Brisbane includes linking Acacia Ridge yard in Brisbane to Sydney. There is currently no direct continuous inland rail link between the two capital cities at each end, with end-to-end rail freight instead moving via Sydney. However, there is a proposed inland railway linking Melbourne and Brisbane via Parkes, Dubbo, Werris Creek, Moree and Toowoomba; this route roughly parallels that of the Newell Highway, entirely bypassing the Sydney region. Investigation of the potential for the development of this proposed rail corridor is currently being conducted; modelling the Melbourne to Brisbane corridor, through the ECFM, may assist in determining the viability of the inland railway route, and help evaluate the merit of investments in the necessary infrastructure.
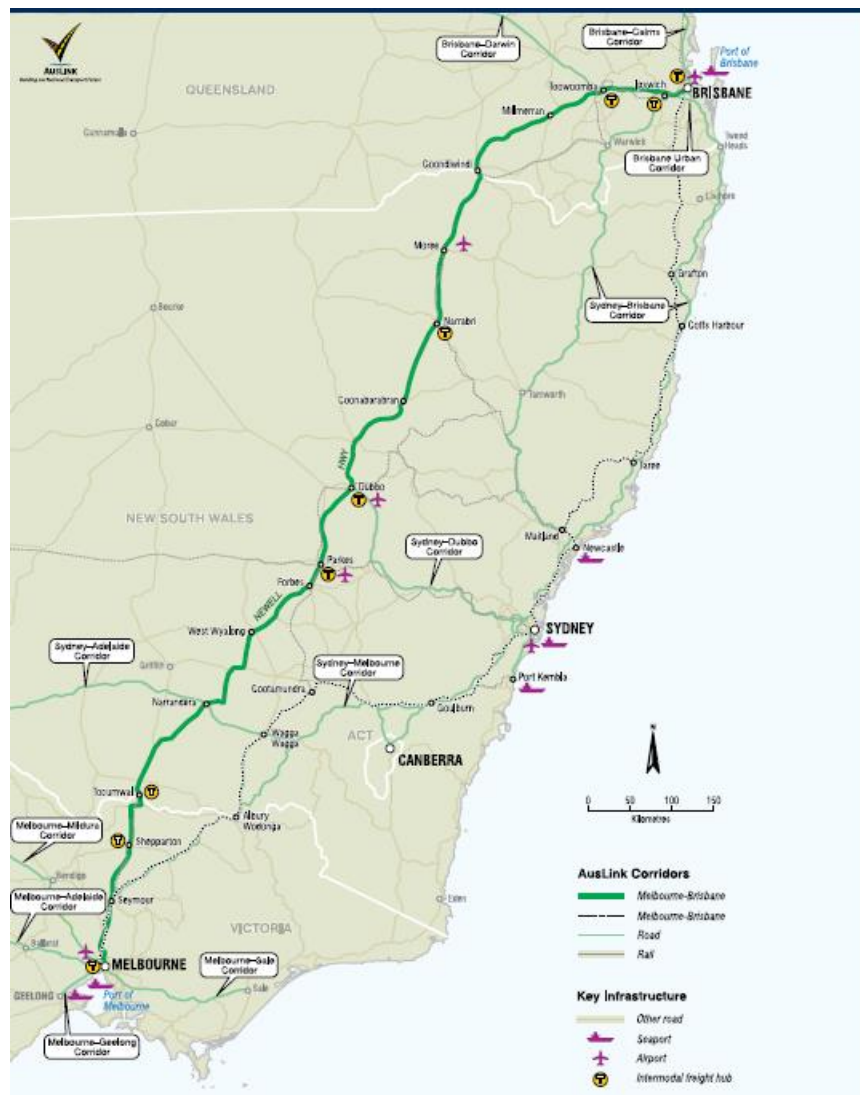
Figure 4.1: The defined National Network for both road and rail between Melbourne and Brisbane (Newell highway route highlighted).
Source: AusLink (2007)

4.4.   Model process

The base-year input for the study would derive from the 2001 ABS FMS database together with other public domain databases such as TERM and WIM. FMS data would then be used to derive the state and regional level O–D by commodity, by mode. In turn, the O–D data would be then used to conduct commodity and mode choice simulation. The commodity flow process in the model conforms to the traditional four-step procedure, which is similar to the Melbourne Freight Movement Model (MFMM) and the Indiana Model in the US. This requires that tonnes of commodities will be generated and distributed and that a mode split component is applied to determine the total tonnes shipped by truck and train modes. The tonnage by mode is converted to trips by mode, and the trips by mode are then assigned to the statewide highway and rail networks. The ECFM will follow the classical four-step approach comprising trip generation, trip distribution, mode split and assignment. The basic procedures for each of these steps in the ECFM are outlined below.

Trip generation: The ECFM will estimate the total freight tonnage by all modes produced (originating) and attracted (terminating) on the East Coast. Production and attraction equations

for the eight commodity groups are based on the relationships with population and employment. Traffic production models are based on the assumption that employment in a particular sector is an accurate indicator of that sector's production. In these models, the key variables are employment and population. Traffic attraction models are based on the assumption that the flows of manufactured goods to a particular market are a function of the demand for that product in two markets: personal consumers and industrial consumers. In the former market, population is the key variable. In the case of industrial consumers, employment is the key variable.

Trip distribution: The ECFM would use a standard gravity model to distribute annual freight tonnage between origins and destinations for the eight commodity groups on the East Coast. The impedance variable for trip distribution is the distance between zones.

Mode split: The mode split is in the form of an incremental logit mode choice model. This incremental mode split model pivots from the base mode shares as identified in the FMS database. The modal split model will consider two individual modes (truck and rail) and one multiple mode category (intermodal). Commodity density factors by commodity are then developed for rail (inbound or outbound). This process yields tonnes by commodity per rail wagonload. These factors are then used to develop density for trucks using the relative difference ratio in loads between rail cars and trucks.

Assignment: The daily truck trip table will be assigned to the highway network using a software-assisted assignment procedure, such as FORTRAN program, based on the travel time between zones. For rail assignment, a 'cost of movement' variable will be developed to incorporate a distance-minimising component, as well as a component related to the magnitude of volume of the rail line.

Figure 4.2 illustrates the model as developed for the base year study. The forecasted year studies follow almost exactly the procedures, using time series population and employment data for different TAZs. Figure 4.3 shows the analysis procedure, with the traffic flow components being identified at various stages.
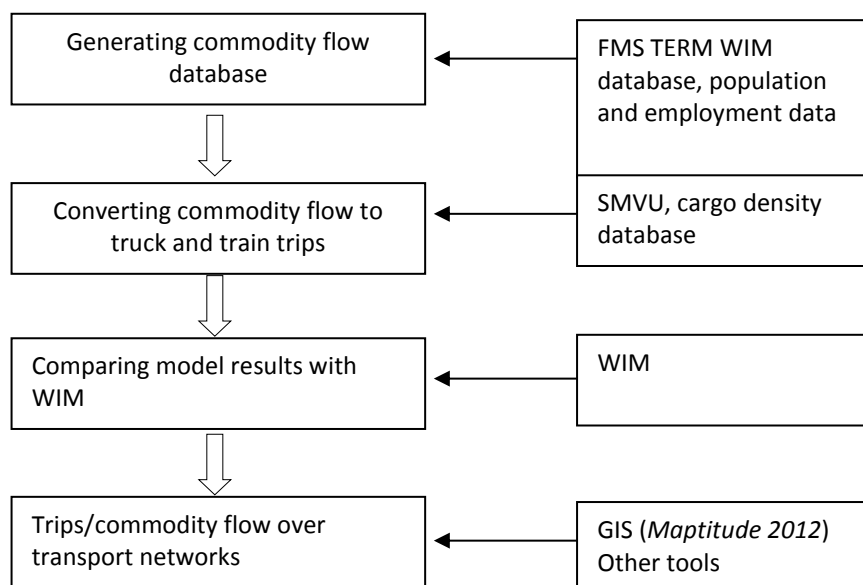

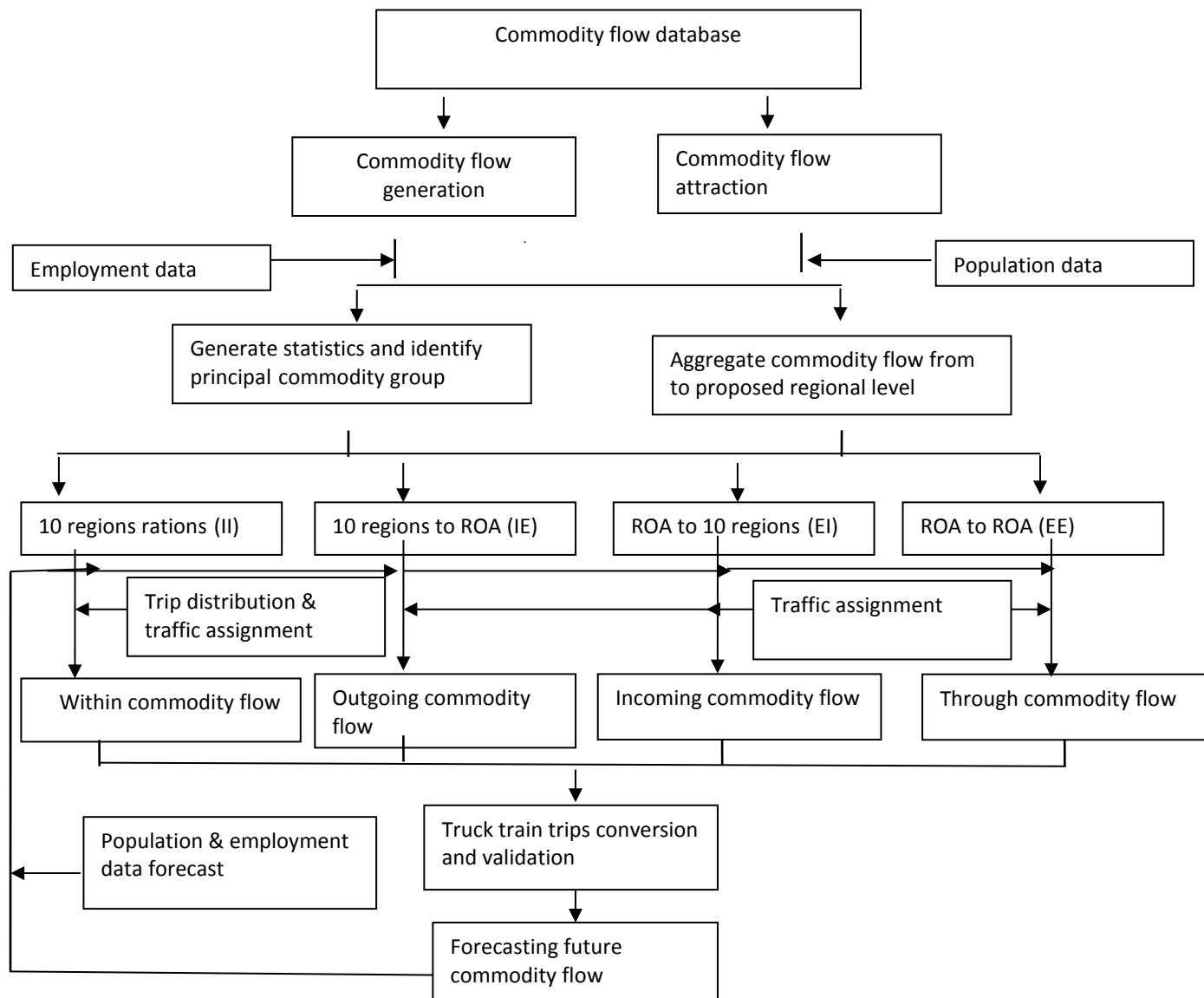**Figure 4.2: Proposed base year study model for the East Coast**

Figure 4.3: Structured analysis procedures for transporatation analysis
Note: ROA (Rest of Australia); II (Internal–Internal); IE (Internal–External); EI (External–Internal) and EE (External–External)

4.5.   Model Validation

Model validation is the process to assure that a model describing a phenomenon does so adequately for the model's intended use (Miser, 1993). Three types of validation have been distinguished in the literature: technical, operational, and dynamic (Gass, 1983). Technical validation refers to the use of the correct kind of data, assumptions, and relations in the model, along with method. Technical validation is also referred to as internal validation (Taylor, 1983). Operational validation assesses the type and importance of errors produced by the model in comparison with reality (i.e., how the model represents reality). Finally, dynamic validation is concerned with determining how well the model predicts over different time periods. Operational and dynamic validation are also referred to as external validation (Taylor, 1983). When the model is shown to be valid for determining contestability between rail and road, it can then be applied to any corridor.

In using this model for the East Coast corridor study, it is proposed to test the operational validity of the model. Operational validation provides information about the practicality of the model and shows the difference between observed reality and the results predicted by the model. This type of validation requires a database that describes an actual situation. The validating database used could be the ARTC's WIM or classified counts.

4.6. Data Requirements

Data sources will be a prime focus in the development, and subsequent scalability, of the ECFM. To apply the ECFM more widely to forecast statewide freight flows, inputs of data are needed to develop and validate the model and methods. Quality and precision are the keys to freight modelling, with the accuracy of the freight flow forecast dependent on the accuracy of the database providing data inputs. If the underlying database is not complete and correct, the estimated freight flow will be inaccurate. This section identifies four types of data required for commodity-based models including:

- data for model development
- data for flow conversion
- network data
- forecasting data.

4.6.1. Data for Model Development

The construction of a commodity flow forecasting model often begins with a freight movement survey. Freight movement surveys gather information about the number of trips, the purpose of these trips, the time the trips were taken, the cost, the distance travelled, the mode choice, and information about the type of freight. A freight movement survey provides the behavioural data to establish the trip generation, trip distribution, mode split, and assignment relationships specific to a study area. The survey size must be sufficiently large to provide a statistically valid sample of all potential freight movements.

Conducting a travel survey around an entire state boundary is generally impractical, and matching vehicles passing through a statewide cordon can be difficult. Generally, administering surveys to freight shippers and carriers is a more manageable approach (NCHRP, 2008). However, identifying a statistically valid sample of shippers and carriers for a statewide survey and determining appropriate expansion factors are complications that make this approach extremely difficult and expensive.

Roadside interviews and traffic counts can provide alternative methods for obtaining road freight traffic data. Both of these approaches are essentially O–D based, and are potentially useful in developing matrices of vehicle movements (Elaurant et al., 2007). In the case of rail freight data, rail operators collect a substantial amount of data on rail freight movement; however, these data collections are typically neither readily usable (having been collected for purposes other than modelling, the data sets are not well arranged for modelling) nor easily accessible (the data concerning commercial matters being generally treated as confidential). Therefore any data that might be made available by rail operators is likely to be aggregated.

Overall, freight movement data availability is quite limited. The picture of freight movement is only partial, which creates difficulties in reconciling disparate data,

especially complicating attempts to distinguish between production and consumption and O–D movements, and between commodities and vehicles (Elaurant et al., 2007).

4.6.2. Flow Conversion Data

Commodity-based methods may require available flow data to be converted into different units for processing or analysis. Specifically, commodity flow data is usually reported and forecast in terms of annual tonnes, but is typically converted into vehicles and economic value (NCHRP, 2008).

Tonnes-to-vehicles

The assignment model component for truck freight on highways is most often calculated in terms of daily truck trips. For commodity models that forecast flow in annual tonnes per year up to, and through, the mode split step, a conversion process is required. The Vehicle Inventory and Use Survey is commonly used (NCHRP, 2008). No recent data is available in Australia and this is a limitation of using an 'ageing' data set, highlighting the difficulty of only having a 'partial picture'.

Tonnes-to-value

Converting tonnes per year into values (i.e., dollars shipped) is useful in economic analysis and in forecasting methods that seek to assess the value of the freight being shipped. These conversion factors are normally obtained from the CFS. Unfortunately, a similar survey is not conducted in Australia and no official statistics are well suited for modelling at this stage.

4.6.3. Network Data

Modelling commodity flow requires networks with physical information about the highway and rail network links. The network used in assigning freight flows must account for characteristics such as segment capacity, volume, free flow speed, and travel time. Many freight shipments use more than one mode in a trip, and data on the intermodal terminals where freight can change modes also are required (NCHRP, 2008). Since many intermodal terminals are privately owned in Australia, this information is rarely publicly available.

4.6.4. Forecasting Data

Population and employment data are the main demand forecasting variables. Population data includes both a base and a forecast horizon year or years for a variety of statistical zones. While employment data are typically used in freight forecasting, the level of industry detail is often insufficient for freight forecasting.

4.7. Data Availability Impediment

As previously noted, data issues influence the practicalities of modelling and the selection of a given approach. As the previous sections have highlighted, data availability presents a substantial challenge for the use of the preferred commodity flow approach. In particular, the data requirements for freight modelling at any level of precision are substantial. The data availability in Australia is summarised in Table 4.3.

Table 4.3: Australian Data Sources for freight modelling.

Data sources	Australian availability
Classical counts	Yes
Vehicle on-road intercept surveys	No
Operator surveys	No
Input output tables	Yes
Commodity flow surveys	No
Import export statistics	Yes
Land use data	No
Rail and road use surveys	Partial
Consignment surveys	No
Operating and consignment costs for road and rail by commodity	No
Historical logistical and operational data	No
One-off surveys	Yes

Source: Elaurant et al. (2007)

The acquisition of data such as vehicle-on-road intercept surveys and operator surveys, and some other missing data sources (see Table 4.3), were extensively considered and data sources sought. Although over time it would be possible to collect this data by, for example, conducting on-road intercept surveys, the time to recruit personnel with appropriate expertise would exceed timeframe available for the project. The implication is that, while the four-step commodity flow model is technically the preferred approach, it is not suitable due to the practical constraints of the modelling task. While it is believed the utility of the methodological framework is sound, the consideration of sources of data made it impractical to pursue.

4.8. Recommended Alternative Approach: Spatial Computable General Equilibrium Model

As the preferred four-step commodity flow approach is impractical, owing to the need to acquire considerable suitable data, an alternative approach is necessary. The newer SCGE approach has less need for data and performs well technically. It is therefore proposed to use an SCGE model for determining contestability of freight by applying an SCGE model to the East Coast corridor. A full proposal has been developed by Professor Edward Chung of the Smart Transport Research Centre at the Queensland University of Technology, and sections of the proposal are reproduced in the following sections.

4.8.1. A Proposed East Coast Corridor Freight Model Using the Spatial Computable General Equilibrium Approach

Project Objectives

The main objectives of the project will be to:
- define the approach for developing a freight transport model for Australia's East Coast corridor
- create a multi-modal freight transport network for the East Coast of Australia
- implement a sketch tool that allows analysis of the possible market share of rail for non-bulk commodities.

Research Methodology

The project will provide an in-depth empirical analysis contributing towards a more holistic understanding of the non-bulk freight flows for both road and rail and estimate current and future freight movements in the East Coast corridor.

Freight Transport Model Roadmap

In contrast to the traditional four-step model, a SCGE model will be used to estimate transport-related and financial and economic impacts on the study area (Figure 4.4). The resulting flows of goods will be loaded into a hyper-network that capable of assigning the freight to optimal modes and routes, taking into account depot and warehouse locations. This approach differs from the ones used in former previous CRC Rail studies that undertook strategic modelling with the help of tools such as FreightSim and TransCAD, using aggregate metrics such as total freight volume between origins and destinations. The SCGE approach is more detailed and will allow greater depth to help evaluate the contestability of rail.
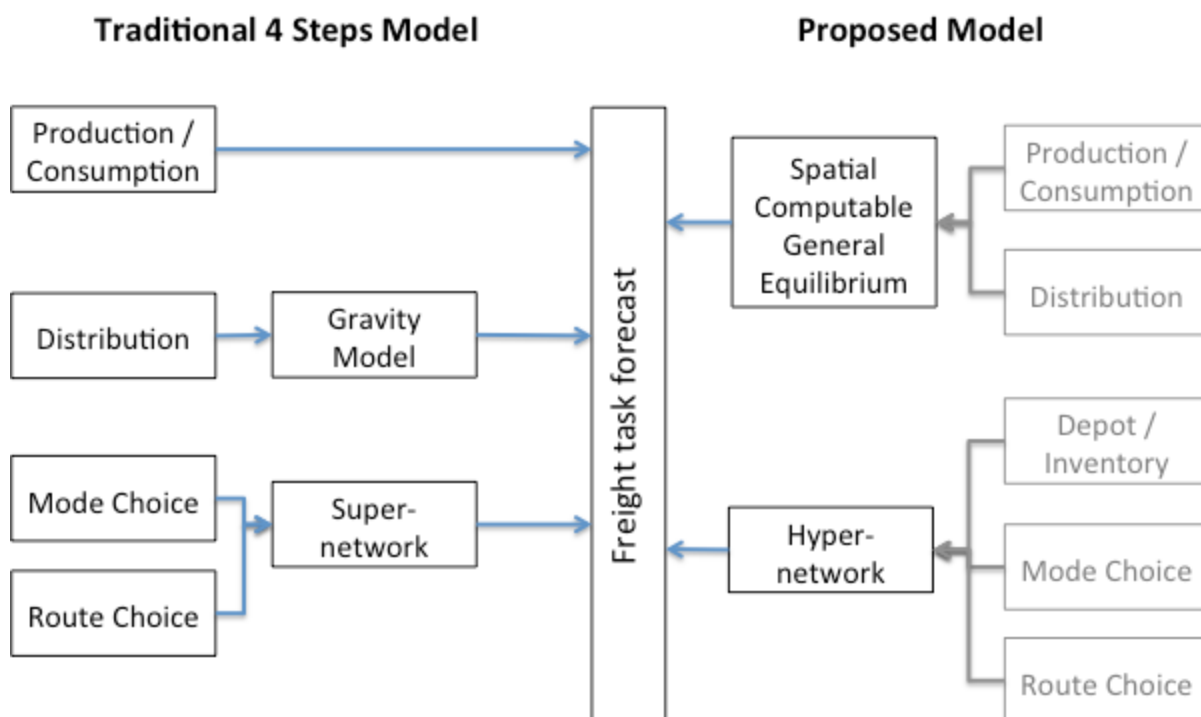

Figure 4.4.   Proposed SCGE model vs traditional four-step modelling of freight task forecasting

The benefit of the proposed model is that the SCGE can perform well without being as data hungry as the traditional four-step model, which is a significantly limitation of the four-step approach.

Sketch Tool

A sketch tool is proposed as part of this project as a platform, rather than a closed application, that allows combining freight with economic linkages, logistics behaviour, as well as freighting trips and networks in a package for policy makers and transport professionals. The sketch tool will allow for the combination of various tools to be combined for sustainability and flexibility. A number of modules will be developed to answer the research question: what non-bulk freight is contestable between road and rail?

SCGE modelling has provided a new tool to model the production, consumption, and trade factors of logistics in a consistent way (i.e., cost–benefit studies). SCGE takes account of inter-sectoral and inter-regional relationships in an economy, making it a suitable tool for obtaining insight into economy-wide, direct and indirect consequences of transport policies. The model replaces conventional I–O and gravity approaches and enriches the theoretical consistency between the fields of economics and freight. This type of modelling has been used for cost–benefit studies relating to rail and port development in Europe (Knaap & Oosterhaven, 2000). In addition, this approach is able to deal with the lack of information that has been detected by the scoping study. For this project, an SCGE model will be developed under the assumptions that four kinds of economic agents (household, firms, government, and transport carriers) exist in each region.

4.8.2. Gaining Contestable Freight

When the amount of contestable, non-bulk freight has been estimated, the project will examine the factors that influence the actual capability to bring about mode shift and gain mode share. Woodburn (2004a, 2004b) showed that a range of factors affect mode shift from road to rail in the United Kingdom. However, the relevance of these factors as barriers to rail achieving a mode shift requires assessment within the Australian context. The proposed model will, therefore, include methods to directly address this issue. Specifically, aAlthough ascertaining which freight is contestable is a key consideration for the project, determining whether a rail freight operator can successfully capture that freight is necessary for rail to increase the freight volumes transported.

While there is a variety of anecdotal material about why freight forwarders and companies with large amounts of non-bulk goods do not choose rail, there is little robust, published evidence about how rail freight operators are perceived by their customers and potential customers. Obtaining this evidence will contribute to a deeper understanding of the influence of these factors in mode choice decisions. This entails consideration of the following types of questions will be considered:

- What image does freight rail present to its potential customers and how does it present that image?
- Do preferential customer relationships exist?
- What communication mechanisms (e.g., websites) do potential customers rely on to inform their decisions about using rail freight?

- Do past 'bad' experiences with freight rail services dictate current perceptions of potential customers and, if so, to what extent?
- Do environmental and sustainability considerations really matter in making transport decisions?

A perception is that the rail industry is not sufficiently 'customer-focused' and is instead primarily concerned with running trains. As part of this project, semi-structured interviews will be conducted with freight forwarders and major industrial shippers of consumer goods to determine their perceptions of rail freight. These interviews ask questions about interactions with rail freight operators compared to road freight competitors and will attempt to pinpoint the issues that the rail freight industry may need to improve to capture freight that, from the modelling work, has been deemed contestable.

5. Conclusion

This scoping study considered ways of determining what non-bulk freight is contestable by rail in Australia. This initial consideration principally concerned: identifying an appropriate modelling approach to address the question of freight contestability and identifying a suitable location for testing the validity of the proposed model to assess its suitability for wider application.

Understanding why and where freight moves and who moves freight is critical for understanding freight corridor mode choice, and ultimately for transport infrastructure investment, land use planning and logistic policies that boost the economic performance of Australia. This report reviewed the existing evidence on factors that influence business decisions around modal choice and the current state of freight modelling practice. The report also evaluated the practical aspects of undertaking a study to determine contestability between rail and road for non-bulk freight. Several important considerations and findings emerged from this scoping study.

A number of factors influence business decisions around modal choice. On the supply side, the principal explanatory variables in the literature are variables such as transport costs, transit time, frequency and reliability and damage rates. On the demand side, the influence of demand characteristics on freight mode choice are not sufficiently understood. Few studies have attempted to systematically establish a relationship between mode choice and freight demand characteristics such as the attributes of the shipper, the attributes of the goods to be transported, and the spatial attributes of shipments.

Various freight modelling tools and methodologies were reviewed. Three broad groups of methods are generally able to respond to the policy and analytical needs of freight modelling
- vehicle-based models focus on modelling commercial vehicle trips
- commodity-based models, such as a commodity flow matrix developed and converted to number of trucks and trains based on static factors from past experience
- a range of inter-agent and integrated economic activity models.

All models and approaches have their own particular strengths and weakness. The choice of modelling ultimately depends on the importance of a number of potentially conflicting technical and practical considerations. The suitability of a given approach must be considered in relation to the goals of the modelling task. There is scope to choose between an existing model, with or without adaptation, or to develop a customised approach, specifically tailored to the task.

To test any model, a freight corridor with rail and highway networks must also be selected. For this project, a suitable corridor must, at least conceptually, allow rail to achieve a substantial increase in non-bulk freight market share, possibly reducing road congestion as well as creating environmental benefits from reductions in greenhouse gas and particulate emissions. In addition, the freight transport environment in the sample corridor should not be overly complex so as to not complicate the initial modelling task. Ideally, relevant actors in the freight corridor will also have an interest in effecting change in practice. Given these considerations, the East Coast corridor of the National Network (Melbourne–Sydney–Brisbane) was selected as the corridor to test the validity of the model.

Development of a four-step commodity flow framework, customised to the modelling task at hand, was initially identified as the preferred approach. A proposed model capable of estimating flows of non-bulk commodities and evaluating the contestability of land transport modes was outlined. However, the data needs of a four-step commodity flow model were high and, in this instance, considerable limitations were identified in terms of the availability of suitable data sources. Possibilities for the acquisition of

data, such as vehicle-on-road intercept surveys and operator surveys, and other data sources were considered. Although, it may be possible to collect this data over time, practical limitations such as time and cost preclude the four-step model from being practical.

Newer methods of modelling such as SCGE models are not as data hungry, and provide a technically sound solution. The scoping study recommended an SCGE approach was proposed as an alternative to the four-step model and a detailed project proposal will be provided separately.

A significant issue identified by the scoping study is that once the contestable freight types and volumes are identified, the next step for the rail industry is to actually achieve the modal shift to rail. There is a perception that rail is not sufficiently customer focused, and this perception may indicate that service factors are impeding potential mode shift. Possible barriers to switching from road to rail may include service quality, reliability and the evolution of logistics systems as rail appears to lag behind providing the service levels required to meet supply chain partners demands. There is little published literature that addresses behavioural barriers or other market segment (commodities) factors across rail and road, meaning that policy makers are unable to obtain a full appreciation of the nature and variety of barriers that be relevant to different sectors or commodities. This scoping study proposes further research in this area through semi-structured interviews with freight forwarders and major industrial shippers of consumer goods to determine their perceptions of rail freight rail, helping to isolate the barriers to a mode shift.

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