FREIGHT DATA REQUIREMENTS STUDY DATA GAP ANALYSIS FINAL REPORT

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Abbreviations

ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
AGIMO	Australian Government Information Management Office
AGLDWG	Australian Government Linked Data Working Group
AIBE	Australian Institute for Business and Economics (UQ)
ALC	Australian Logistics Council
ANAO	Australian National Audit Office
ANDS	Australian National Data Service
API	Application Programming Interface
APP	Australian Privacy Principle
ARC	Australian Research Council
ARRB	Australian Road Research Board
ASAC	Australian Statistics Advisory Council
ATDAN	Australian Transport Data Action Network
AURIN	Australian Urban Research Infrastructure Network
BITRE	Bureau of Infrastructure, Transport and Regional Economics
CAV	Connected and Automated Vehicles
CBA	Cost Benefit Analysis
CITS	Co-operative ITS
COAG	Council of Australian Governments
CRC	Cooperative Research Centre
CSCL	Centre for Supply Chain and Logistics
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIRDC	Department of Infrastructure, Regional Development and Cities
DFAT	Department of Foreign Affairs and Trade
DPMC	Department of Prime Minister and Cabinet
DTA	Digital Transformation Agency

DTO	Digital Transformation Office
FMS	Freight Movements Survey
FOI	Freedom of Information
GIF	Graphics Interchange Format
GIS	Geographic Information System
G-NAF	Geocoded National Address File
GPS	Global Positioning System
GVA	Gross value added
HILDA	Household, Income and Labour Dynamics Australia
IAP	Intelligent Access Program
ICT	Information and Communications Technology
IDI	Integrated Data Infrastructure
iMOVE	iMOVE Australia (incorporating the iMOVE Co-operative Research Centre)
LBE	Large business enterprise
IoT	Internet of Things
IP	Internet Protocol
IPA	Infrastructure Partnerships Australia
IT	Information Technology
ITS	Intelligent Transportation Systems
JSON	JavaScript Object Notation
MaaS	Mobility as a Service
MADIP	Multi-Agency Data Integration Project
MBE	Medium business enterprises
MOG	Machinery of Government
MOU	Memorandum of Understanding
NCRIS	National Collaborative Research Infrastructure Strategy
NDC	National Data Custodian
NFSC	National Freight and Supply Chain (Strategy)

NID	National Interest Dataset
NHVR	National Heavy Vehicle Regulator
NSS	National Statistical Service
NTC	National Transport Commission
NSW DAC	New South Wales Data Analytics Centre
OAIC	Office of the Australian Information Commissioner
OECD	Organisation for Economic Co-operation and Development
PC	Productivity Commission
rCITI	Research Centre for Integrated Transport Innovation (UNSW)
SBE	Small business enterprises (LBEs)
SMART	SMART Infrastructure Facility, University of Wollongong
SMVU	Survey of Motor Vehicle Use
TCA	Transport Certification Australia
TIC	Transport and Infrastructure Council
TfNSW	Transport for New South Wales
TMR	Department of Transport and Main Roads Queensland

1 Introduction

Datasets play a vital role in helping governments, industry and other stakeholders better understand how, how fast, how well and where land freight is moving around the country. Firms require information about operating costs, market opportunities and the performance of the freight supply-chain ecosystem in which they operate. Federal, state and local governments, as the custodians of most of the national freight supply-chain network, are responsible for making investment decisions to meet expanding demand for freight services in a growing economy.

This chapter identifies the freight data landscape in Australia. In doing so, we identify and classify over 350 data sources, produced by firms, industry associations, and all levels of government. We also identify and classify several data gaps which, in our view, are potentially material to the overall performance of Australia's freight supply-chain.

Several data gaps and industry needs were revealed as a result of the consultation process (see Chapter 2). The industry frequently highlighted several issues such as an inconsistency in data collection, standards, publishing frequency, the high level of aggregation (which is not fit-for-purpose), a general lack of coordination in data collection/dissemination, and a lack of cooperation between the public and private sector.

These comments have been confirmed in our review of existing freight datasets. For example, the Bureau of Infrastructure, Transport and Regional Economics (BITRE) and the Australian Bureau of Statistics (ABS) provide productivity indicators in terms of aggregated figures (such as tonnage or tonne-kilometres travelled). However, the data sources for these indicators do not readily allow for sophisticated analysis (such as relative freight costs between transport modes, the interrelation between other sectors (manufacturing, mining, agricultural and etc.), and service delivery performance analysis.

While the benefits of more detailed freight information are clear, there exist a number of impediments and important trade-offs such as the costs of collection, analysis and dissemination, confidentiality issues and lack of coordination between data users, collectors and disseminators. As the BITRE (2018a) has noted, the datasets may exist, but they remain difficult to access. A key issue will be how privately-owned data should be utilised and what the 'win-win' solution could look like. Some of the private datasets may be of considerable benefit to policymakers, such as GPS tracking data. However, their public release could directly undermine the owner's business model by giving away their intellectual property and core competitive advantage.

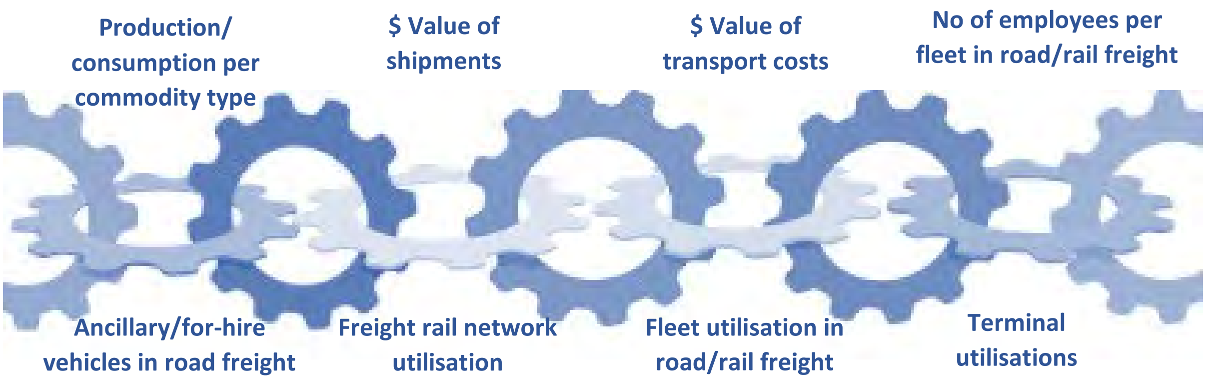
Many issues will need to be resolved in order to better coordinate existing public and private datasets, including: legacy systems, interoperability, siloed data, and a lack of skills in data survey design. While centralising the existing freight datasets can be a solution, it is obvious that both the government and private businesses wish to retain control of their datasets to preserve their confidentiality (and bureaucratic control in some cases), and commercial benefits. However, in theory, these impediments can be overcome by innovative approaches to apportioning costs and benefits between organisations sharing data, and developing data accessibility models with different degrees of openness. The challenges of developing appropriate and acceptable mechanisms for sharing data owned by the private sector or protected by confidentiality are pivotal to promoting the spread of data usage by the transport industry.

1.1 Policy context

The fact that the freight transport industry, taken as a whole network, suffers from information gaps is not new and, in fact, can be deduced from standard economic and public policy analysis of our federal structure and the complicated ownership structure of the freight network. For example, in the late 2000's it was recognised that a coordinated national policy framework was needed. In 2008, the 'Strategic Research and Technology (SRT) Working Group' was established with a remit to focus on key transport data requirements. Also, around this time ABS and BITRE undertook a Strategic Review of Transport Statistics where a set of critical transport data gaps were identified. The data gaps were subsequently addressed using a survey methodology, namely the Transport Activity Survey (TAS), the Freight Movement Survey (FMS), and a revised Survey of Motor Vehicle Use (SMVU). These surveys have been at the core of transport data collection over the past decade, particularly in freight transportation.

In 2016, the National Transport Commission (NTC) completed two projects to identify gaps in freight data, in relation to the National Land Transport Productivity Framework. Figure 1-1 indicates the major data gaps that have been observed in the "Who Moves What Where" study by NTC (2017).

Figure 1-1. Major freight data gaps in "Who Moves What Where" study by NTC (2017)



The National Infrastructure Data Collection and Dissemination Plan has been developed by BITRE and the ABS with the goal of filling key data gaps and develop performance data. A Steering Group made up of infrastructure and transport experts from across the public sector, industry and academia was established to develop priority projects to improve the way infrastructure data is collected, shared and used to guide decision making. The Final Data Collection Plan, released in 2018, provides a list of 16 priority projects to help achieve its purpose, as follows:

- Heavy Vehicle Infrastructure Asset Register;
- Infrastructure Performance Dashboard;

- Freight Performance Indicators;
- Network Optimisation Frameworks;
- Measuring Transport's Contribution to the Economy – Transport Satellite Account;
- Non-Fatal Road Injury Data;
- Customs Freight Data Analysis Project;
- Road Freight Telematics Data Collection; and
- Road Operator Data to Support Connected and Automated Driving.

Two examples of these projects that have been already implemented by BITRE are: (1) an interactive online Infrastructure Performance Dashboard, and (2) a project using truck GPS data to identify where congestion is impacting freight movements in the Sydney greater metropolitan area.

The ALC (2018c) recommended a number of priorities for providing the common datasets for Australia's freight supply chain, as follows:

- Increase the Department of Infrastructure, Regional Development and Cities' (DIRDC's) capacity for technological and operational trend analysis and enhance its engagement with industry on potential trends and innovation in the logistcs sector and wider economy, and ensure regulations enable the adoption of new technology and innovation.
- Encourage adoption of global data standards and collaborative electronic platforms across all freight modes to streamline the exchange, comparison, and understanding of data within the land, sea and air freight sectors.
    - For example, port community systems utilise a common electronic platform to connect multiple systems operated by the different organisations that make up a sea port community, such as: stevedores; vessel operators; slot charterers; freight forwarders / customs brokers; road and rail landside container carriers.
- Bring forward the proposed 2019 Productivity Commission review of rail and road operating frameworks to 2018, including a focus on productivity, harmonisation of standards, safety and regulation.
- Streamline the route permit approval process (including responsibility for decision making, and funding) for heavy vehicles (including oversize and over mass vehicles) by local governments and associated regulations, with a view to establishing a national design standard/policy and reducing the approval period to 24 hours on key freight routes in line with national best practice.

In relation to the Measurement of freight performance, the Australian Logistics Council (ALC, 2018b) provided a number of recommendations related to enhanced data collection and benchmarking freight performance, such as:

- Establish a data gathering and performance review mechanism focused on travel times and reliability on key freight routes and the efficiency of the interfaces at freight terminals with routine public reporting of performance over time.
- Benchmark key export supply chain performance against international competitors.
- Ensure the National Digital Economy Strategy, set up by the Australian Government in September 2017 to focus on ways governments, businesses and the community can seize the benefits of digital transformation, incorporates recommendations on freight priorities to create efficiencies. As an example, port community systems mentioned in priority 1.3 could be expanded.
- Fund the Australian Bureau of Statistics to establish a transport satellite account to its national accounts that separately reports the value of freight transport for the economy as a whole (eg. GDP, employment, etc.).
- Fund a freight observatory to collect, analyse and publish freight performance data for all freight modes and supply chains to better inform decision making and investment, with appropriate governance arrangements and the potential for this function to be held by an independent body that has industry confidence.
- Develop a better understanding of regional air freight requirements to enhance regional export opportunities, for example through airport upgrades and/or improved road, or domestic air, connections to international airport gateways.
- Introduce a 'chain of productivity' concept into supply chain monitoring that would involve developing guidelines and processes to measure and report performance throughout the supply chain, including freight vehicles and freight terminals.

In relation to freight dataset collection and monitoring the supply chain more generally, the ALC (2018d) provided three recommendations, as follows:

- The dedicated Freight and Supply Chain Unit within DIRDC be immediately tasked with establishing a data gathering and performance review mechanism that measures and reports the performance of key freight routes and interfaces at freight terminals.
- That the Commonwealth Government allocate a portion of the monies appropriated in the 2018/19 Commonwealth Budget to assist the implementation of the National Freight and Supply Chain Strategy to the ABS, to complete the establishment of a transport satellite account.
- That the Commonwealth Government engage with port operators and supply chain participants to identify areas where government-mandated documentation related to the import and export of goods can be digitised and streamlined.

1.2 Purpose of freight data collection

Essentially, there are two purposes to collecting freight data which reflect two different stakeholder perspectives, as follows:

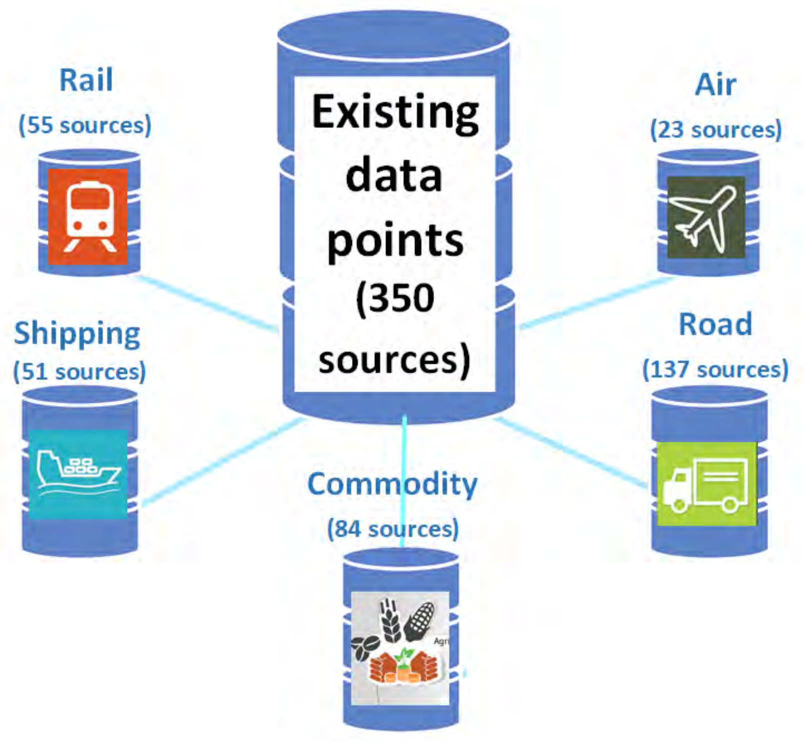
1. Improve real-time and longer-term operational efficiency, which involves:
    - Firms collecting and analysing data about themselves and their competitors, and undertaking modelling (eg. forecasting), which can improve profitability (and overall productive efficiency across the network); and
2. Improve long-term network performance, which involves:
    - Governments (as owners and financers) collecting and analysing data for the purposes of making better, and more timely, infrastructure investment decisions, which in turn promotes allocative and dynamic efficiency.

Improved freight data collection can also realise other goals, such as:

3. **Innovation**. Stimulating and facilitating research and innovation with improved understanding and efficiencies across the supply chain, including interoperability, solutions for complex multi-modal options, e-commerce, scaling up at the global market, and creating new ideas for disruptive technologies.
4. **Communication.** Assisting governments and industry to communicate freight issues better, provide a transparent picture to the community about the effects of freight services, and garner community support for major city and regional shaping investments, reporting, performance analysis and reconciliation.
5. **Standardisation, harmonisation and visibility.** Developing standard freight data and harmonised indicators, improving the availability and visibility of data among stakeholders and between private and public sectors.

In this review, a dual approach (commodity-based, and mode-specific) was used to catalogue the current datasets and previous efforts in information integration across two levels of government (federal and state) and the private sector (Figure 1-2). Over 350 data sources were reviewed, and various attributes of datasets and data points were documented, such as: the length of data series, the dataset release formats, and key data users. Accordingly, a spreadsheet was compiled from all the existing datasets and reports for all transport modes (road, rail, air, sea and coastal), and commodity groups across the three groups (federal and state government, and the private sector).

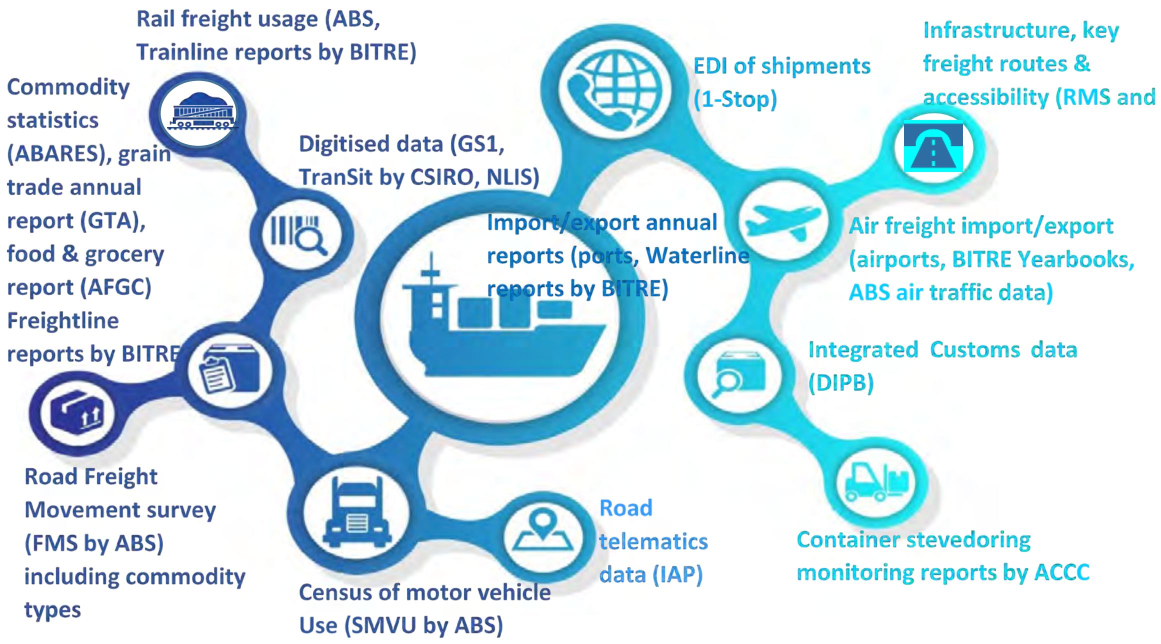
Figure 1-2. Reviewed data points in this chapter



This review indicates that numerous statistics that are useful in describing the transport and logistics task in Australia are available from a range of published and private sources.

Figure 1-3 below presents a schematic of many of the previously mentioned data sets including Freightline, Trainline, Waterline reports by BITRE, SMVU and FMS by ABS, Customs import/export data, Road telematics data (IAP), Data standards (GS1), Commodity freight models (TraNSIT)and even freight ID (NLIS).

Figure 1-3. Main existing freight data



While clearly there is not a 'freight data drought' in Australia in terms of government publications, it is important to scan private sector data collections as well to clearly understand where the freight data gaps are, and their significance. In this regard, Table 1-1 represents the key data collectors, analysers, disseminators, and open data portals that were reviewed in this study.

Table 1-1. Key data point holders

Type	Primary collector	Collector and analyser	Disseminator	Open Data portal
Commonwealth Government	Australian Bureau of Statistics (ABS)	Bureau of Infrastructure, Transport and Regional Economics (BITRE)	National Transport Commission (NTC)	Data.gov portal
	Department of Foreign Affairs and Trade (DFAT)	Australian Logistics Council (ALC)	Australian Competition and Consumer Commission	
		Bureau of Resources and Energy Economics (BREE)		
		Ports Australia		
		The Department of Natural Resources Mines and Energy (DNRME)		
		Department of Agriculture, Fisheries and Forestry		
		Australian Bureau of Agricultural and Resource Economics (ABARES)		
		Department of Infrastructure and Regional Development and Cities (DIRDC)		
State governments		Queensland government • Department of Transport and Main Roads (TMR)		Data Queensland government
		South Australia government		Data SA
		Vitoria State Government • VicRoads • Department of Economic Development, Jobs, Transport & Resources (DEDJTR)		Victorian Government Data Directory

Type	Primary collector	Collector and analyser	Disseminator	Open Data portal
		NSW government • Digital Topographic Database (DTDB) • Department of Planning, Transport and Infrastructure • Transport for NSW • Transport, Roads and Maritime Services		Data NSW
		WA government • Department of Transport • WA Environmental Protection Authority		Open Data Portal for Western Australia
		ACT government • Roads ACT		ACT Open Data Portal
		Tasmania government • Department of State Growth • TAS Department of Infrastructure, Energy and Resources		TAS Data
		NT government		Digital Territory
Government-supported organisations		South Australia Freight Council - SA		
		New South Wales Mineral Council Ltd. - NSW		
		Freight and Logistics Council of WA		
		Queensland Transport and Logistics Council (QTLC) - QLD		
		Transport, Housing and Local Government Committee		
		The Australian Industry and Skills Committee (AISC)		
		Austroads		

Type	Primary collector	Collector and analyser	Disseminator	Open Data portal
Research Organisations		AgriFutures Australia (Rural Industries Research and Development Corporation)		
		ARRB		
		CSIRO and Data61		
Private parties		Qantas freight		
		ARTC and Arc Infrastructure		
		John Holland		
		Port Botany		
		Port of Brisbane		
		Port of Melbourne		
		Port of Fremantle		
		Port of Adelaide		
		IBIS World		
		Consulting reports		

1.3 Findings and conclusions

There is a plethora of freight related datasets in Australia, collected by all levels of government in the Australian federation, as well as private firms (particularly larger firms) and industry bodies. However, we also find significant gaps in the datasets, most notably in relation to how data with common characteristics (say, by commodity or mode) is not comparable across supply-chains, regions or states because it is not standardised and concorded to the same levels of aggregation or granularity or collection frequency.

That said, this review has shown that the Australian government and leading states, such as NSW, have begun to embrace open data principles. Two good examples of this new approach are the IP Australia open data model, and Transport for NSW's (TfNSW's) commitment to 'open' and 'easy' access to some freight government data.[1] This new approach has the potential to improve the efficiency of Australia's freight supply chain through improved private and public sector decision-making (supported by new and innovative analytical approaches). However, while we have observed that most state government transport departments have developed an open data portal policy and architecture, not all departments have provided the same quantity of data in a consistent and accessible format.

This study also indicated several other problems with government data release. For instance, because the government doesn't generally release the underlying raw data, it must necessarily make a call on the level of data aggregation, which will clearly not suit every data user. Another common criticism is that data are often released with significant delay. This criticism is relatively recent and is driven by the fact that modern information and communications technology means that information in other aspects of life are released in real-time. Comparing this to the delays in publishing ABS surveys such as SMVU and FMS, for example, which in some instances occur two years after collection (and in a highly aggregated form that prevents modelling and forecasting precision), reflects poorly on modern government approaches to data dissemination.

The remainder of this chapter is organised as follows. The next section presents the background for identifying the main areas for this review. Then, the existing data and information gaps are identified are presented. The last section of this chapter outlines the main data gaps and summarises the main findings.

[1] https://data.gov.au

2 Background and Motivation

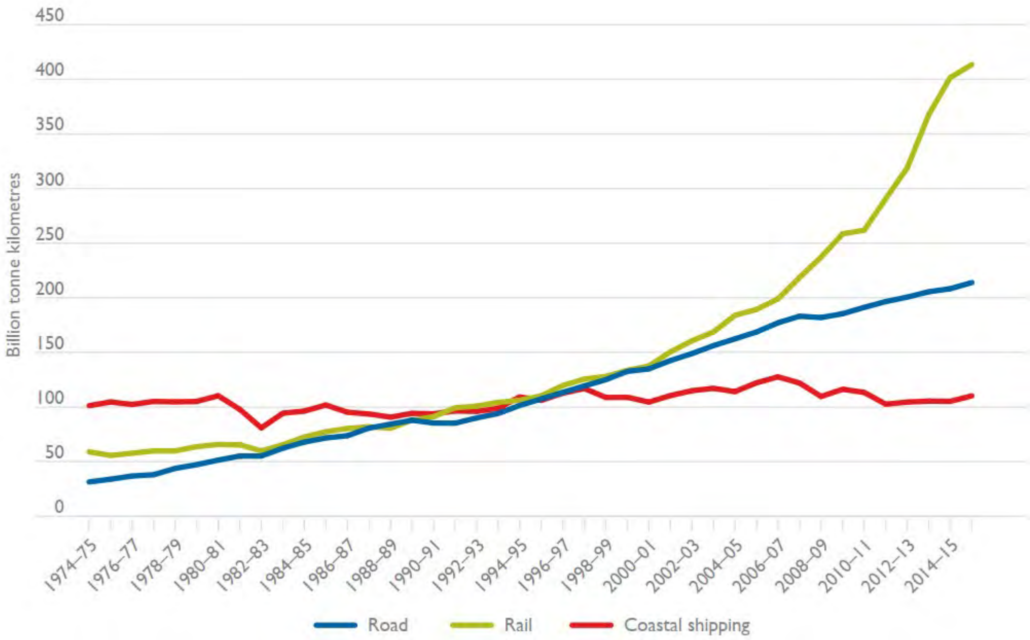
2.1 Australia's freight task is growing

Freight is moved across vast distances in Australia due to the size of the country and the dispersed locations of its agricultural, mining, production and population centres. Indeed, Australia has long lived with what historian Geoffrey Blainey famously described in 1966 as the 'tyranny of distance'. Australia's unique status of being a geographically large country with a relatively small highly urbanised population has always meant that our freight supply chains are vital to national economic performance and the overall wellbeing of the Australian people.

Largely as a result of the mining investment boom (2003-2012), Australia experienced more rapid population growth during this period. This, in turn, placed enormous pressure on our transport networks, particularly in the gateway cities of Sydney and Melbourne where freight competes with private vehicles and public transport for scarce 'slots'.

The freight task is usually measured in total tonne-kilometres which is the product of reported average load (tonnes), and total kilometres travelled for each vehicle type. BITRE (2018f) classify transport statistics by type (i.e. freight (by commodity) or passengers), and by mode (road, rail, aviation or shipping). Figure 2-1 below illustrates the growth of Australia's domestic freight task (by mode and measured in tonne-kilometres) between 1974-75 and 2014-15.

Figure 2-1. Australian domestic freight task, by mode of transport



The figure illustrates that the Australian domestic freight task has been increasing strongly for the last 40 years, with road and rail freight now dominating domestic freight activity. The rapid growth in the rail freight task through the mining boom period (2003-2012) has been largely driven by rail's movement of iron ore in the Pilbara region (BITRE, 2018f). Indeed, BITRE (2014a) has estimated that there has been a quadrupling of mining-related rail freight volumes over the last 40 years (primarily iron ore in WA and coal in Queensland and NSW). However, Australian coastal shipping freight volumes grew very little over that period, and more recently have declined due principally to lower volumes of domestically produced petroleum.

2.2 The importance of seasonal variation of freight task for planning

The seasonal variation in freight activity is identified as one the factors having significant negative impacts on the port, rail, and road market in terms of the level of demand for import and export movement, in addition to operational efficiency. The causes of seasonal variability are known as: (1) seasonal fluctuations in the growth and harvesting of grains, cotton, fruit, vegetables, meat and livestock and other agricultural commodities; (2) weather related patterns of agricultural export products (grains, cotton, meat) and the related importation of farm machinery and fertilisers; and (3) trends in the construction and mining industries which influence the import of containerized construction materials and cargo through ports. The dispersed nature of agricultural production, mining, and project cargo across the nation, aside from the seasonal variability, makes it difficult to predict and plan long-term freight solutions and infrastructure investment.

With increased information on seasonal variations and the dynamics of international trade, governments can pursue a more systematic approach to public and private investment planning and funding. For example, the seasonality of most agricultural commodities means the producers do not require a constant freight service in specific regions and latitudes but do require significant amounts of freight moved during what is sometimes a very short peak production period (THLGC, 2014).

2.3 Assembling a ‘big-picture’ through end-to-end supply chain visibility

Supply chain visibility is important for firms, industry associations and government. For firms, understanding the whole supply-chain can help minimise costs. For industry associations, this visibility helps with the collection, analysis and dissemination of important information to individual firms and assists with communicating to the government in relation to policy. For governments, supply chain visibility provides vital information for planning, regulation and public investment.

Supply chain visibility is defined as the ability of parts, components or products in transit to be tracked from the manufacturer to their final destination. Supply chain visibility enables firms to reconfigure their supply chain resources for greater competitive advantage (Wei and Wang, 2010). In addition to providing an accurate, real-time picture of demand signals and supplier inventory levels, manufacturers are using visibility to help meet compliance directives related to trade practices, environmental mandates and track-and-trace laws. In many industries, supply chain visibility programs are aligned with disaster recovery plans (Rouse, 2009). Accordingly, supply chain activity and performance must be measured to monitor domestic and global competitiveness over time and identify areas where action is required to maintain and improve productivity. The supply chain features vary based on the type of commodities.

2.4 Technological advances – visibility, integration and compliance

Over recent decades, both governments and the transport logistics industry have swiftly adopted advanced technologies such as road telematics data, Radio Frequency Identification (RFID), and Electronic Data Interchange (EDI) to: (i) ensure legal compliance, and (ii) to enhance supply chain visibility, traceability and productivity. These data, potentially, have enormous positive spill-over benefits for the Australian community via better analysis and decision-making by governments, supporting by good research.

One key question is whether the speed of technology adoption in the Australian logistics sector has been satisfactory from the perspective of the relative performance of the sector?

While leading companies are already adopting state-of-the-art technologies to maintain and enhance their competitiveness, the uptake among smaller firms is slower. Hence, the applicability of new data developments will have variable relevance and interest to different companies across the spectrum of competitiveness in the industries concerned. That said, any assessment of data needs should account for all industry participants, and should ensure accessibility and value to each.

In 2017, the Austroads pilot study: "End-to-end Supply Chain Visibility" demonstrated the benefits of increased data collection in terms of efficiency, integrity, connectivity, visibility and near- and long-term innovations (Austroads, 2017). This pilot study confirmed that Global Data Standard (GDS) technologies are important precursors for visibility in supply chains and indicated that the dynamic capabilities of the logistics service providers were enhanced through reduced turnaround times and on-time delivery failures. Accordingly, this practice showed that transport businesses are proponents of highly customised IT systems (eg. sharing 'one up-one down' parties across the chain) to maintain their business competitiveness.

Initially, transport operators saw the costs of adoption of GDS as a cost of doing business and complying with customer requirements rather than offering additional value to their businesses. However, as the pilot progressed the dynamic capabilities of transport providers were enhanced regarding improved planning, reducing turn-around times, and delay and failure costs.

Another example that demonstrates the potential benefits of data compliance and sharing is the Intelligent Access Program (IAP), which is the first use of telematics within the national regulatory framework for managing heavy vehicles in Australia. This program, which is supported by all government road agencies in Australia, includes a large GPS dataset first developed in 2011. Once a transport operator has enrolled in the IAP, the vehicle is assigned a telematics 'black box' (In-Vehicle Unit or IVU) and a Self-Declaration Input Device (SDID). The IVU and SDID gather data from the vehicle and return it to the IAP for monitoring. The IVU is installed in the prime mover and monitors that vehicle in isolation – it cannot be associated with more than one vehicle or switched between two vehicles. The incentive for freight operators to participate in this plan is to receive improved access to particular roads in exchange for compliance. This program has demonstrated an increasing number of enrolments of freight operators during the last seven years.

Although this programme aims to assure road authorities that heavy vehicles operating under the programme are compliant with the appropriate conditions, there are many known (and unknown) potential uses for policymakers arising from this granular dataset. Hence, exploring these datasets and designing possible incentivisation programs is important.

2.5 Data on labour, fleet and operators is critical

Freight transport employment data is important for a number of reasons. First, governments have a core policy objective of sustained employment growth and maintaining low unemployment across all industries and regions, including in freight transport. Second, from a firm point of view, labour is both an asset and a cost that needs to be developed and managed effectively. Shortages of skilled labour, for example, can adversely affect industry prospects in the short- and long-term. Additionally, both government and industry maintain a focus on gender diversity. Therefore, relevant statistics are important to track the performance of the transport industry against the goal of greater female participation in the industry.[2]

2.6 Transport networks enhance economic growth

Transport networks can significantly enhance economic growth and living standards by linking together the factors of production in a complex web of relationships between producers and consumers (Rodrigue and Notteboom, 2018).[3] The cost of moving goods is a substantial component of the overall cost of production for many industries. Therefore, improving the efficiency of the transport task can have a material bearing on the final cost of production and, hence, level of competitiveness.

Economic integration via the services provided by transport networks generally leads to a more efficient division of production by exploiting comparative geographical advantages (such as between urban and rural regions), achieving both economies of scale and scope. The productivity of space, capital and labour are thereby enhanced by the efficiency of distribution and, importantly, personal mobility. Accordingly, freight transport infrastructure is a vital enabler of economic growth. So-called 'soft assets', namely labour, management and information systems are also essential. Planning and investment decisions have to be made about how to use and operate transportation systems in a manner that optimises benefits and minimises costs and inconvenience (for both freight and passengers).

Measuring the economic contribution of the freight task provides governments with a basis to develop evidence-based transport policies (including investment decisions). This measurement needs data about transport financial and volume data, proportional value of goods, transport cost per mode/commodity/logistics chain unit of shipment. This analysis can be assisted by the development of the transport satellite account (TrSA).

[2] Women are significantly underrepresented in senior management roles, board positions and more generally across the wider transport and logistics workforce (TMR, 2018f. State Controlled Roads Bridges - Queensland. Queensland Government). In response ALC launched a significant policy initiative in 2015 to increase and encourage greater diversity in the logistics industry ibid.

[3] In economic theory, the factors of production are most commonly defined as land, labour and capital.

2.7 Sustainable freight transport supports economic and social value

While there is much debate about the impacts that transport and logistics on the environment and whether these impacts could or should be mitigated, it is clear that the environment is increasingly becoming part of the ongoing transport and logistics policy discussion. The freight industry can have adverse noise and air pollution impacts, particularly on communities living in close proximity to major freight routes. Diesel heavy vehicles and light trucks contribute disproportionately to particulate and nitrogen oxide emissions. This is partly due to a large amount of fuel they consume and also the age of many freight vehicles - older vehicles are high emitters of fine particles. That said, many regulations exist to limit noise and air pollution and the Australian Government has committed to a carbon emissions target, which includes the transport sector.

According to SAFC (2014), freight transport impacts on the environment can be categorised under the following:

- **Air Quality** – impact of gas and particulate emissions on health;
- **Greenhouse Gas Emissions** – impact of emissions affecting the ozone layer and climate;
- **Noise** – impacts on amenity and health;
- **Energy** – consumption of non-renewable energy;
- **Water Quality** – impact on hydrological conditions, including contamination;
- **Soil Quality** – impact on soil erosion and contamination;
- **Land Take** – impact of facilities/freight corridors on land use, access and landscape; and
- **Biodiversity** – impact of reducing diversity of flora and fauna.

3 Data Review

In this section, we review the existing datasets, disseminated reports and information under eight categories as follows:

1. Freight task
2. Supply chain visibility
3. Co-ordination and integration of supply chain and logistics
4. Productivity measures
5. Labour, fleet, and operators
6. Network, infrastructure, and land use
7. Cost and economic contribution of freight
8. Freight transport safety

3.1 Data on the freight task

The freight task is usually measured in total tonne-kilometres which is the product of reported average load and total (business) kilometres for each vehicle type that can be reported per mode and/or per commodity.

3.1.1 Road freight task

The ABS is the primary sources of statistics for Australia's road freight task. The ABS conducts the Survey of Motor Vehicle Use (SMVU) regularly and Road Freight Movement Survey (RFMS) as an ad-hoc basis and as a component of SMVU.

Since the introduction of SMVU by the ABS in early 1970s, the ABS has used a limited concept of the interstate road freight task. This interstate road freight task was defined as the amount of tonne-kilometres done by other states' trucks on a state's road. Moreover, from 1971 to 1995, the SMVU was conducted every three to five years. Since 1998, it has been conducted annually. Because there is no overlap between the samples selected in consecutive years, it has not been specifically designed to measure the change between years. It worth mentioning that due to the methodological adjustment in 1998, caution must be used when using the SMVU for time-series analysis. However, BTRE completed a major exercise in adjusting past SMVU freight data to make it comparable to the current SMVU methodology (BITRE, 2006). Accordingly, the road freight task published by ABS can be only historically analysed for the SMVU data for 2007, 2010, 2012, 2014 and 2016.

In the latest SMVU collected in the financial year of 2015-16 and published in March 2017 by ABS (2017), the nationwide freight task data for the 12 months ended 30 June 2016, was outlined as follows:

- Motor vehicle use, by state/territory of registration by type of vehicle
- Total and Average kilometres travelled, by state and territory of registration by type of vehicle by area of operation / by state and territory of registration by type of vehicle by business and private use / by area of operation by type of vehicle by type of fuel / by year of manufacture by type of vehicle by state/territory of registration / by state of operation by type of vehicle
- Total and average tonne-kilometres, by type of vehicle by state and territory of registration / by state and territory of registration by type of vehicle by area of operation / by type of vehicle by state and territory of operation / by state and territory of registration by state and territory of operation
- Total tonnes carried freight vehicles, by state/territory of registration by type of vehicle by commodity
- Total load carried and average load per trip, by state/territory of registration by freight vehicles
- Total kilometres travelled, by state/territory of registration by type of vehicle by main type of journey
- Total and average tonne-kilometres rigid trucks, by number of axles by gross vehicle/combination mass by state/territory of registration
- Total and average tonne-kilometres articulated trucks, by trailer configuration by gross combination mass by state/territory of registration

The Road Freight Movements Survey (RFMS), also was conducted as an additional component of the SMVU in 2014, from Nov 2013 to October 2014 and was published in October 2015 (ABS, 2015). The RFMS provides estimates of freight moved by road for 2013-2014, collected on a sample survey of articulated and rigid trucks only that were registered with an Australian motor vehicle registry. Notably, other vehicles were excluded from the scope of the survey. Respondents were asked to provide information about their vehicle configuration, the load carried and origin-destination for all trips undertaken within a randomly allocated reference week. The RFMS include freight flows between geographic areas, classified by origin, destination, commodity and method (solid bulk, other bulk (liquid/gas), containerised or other) and whether the goods are dangerous and/or refrigerated. Data on commodity uses selected articles (21 items) from the Australian Transport Freight Commodity Classification (ATFCC) and whether these goods are categorised as dangerous. This data and the SMVU are available in the 'TableBuilder' format at the more disaggregated version (SA3 level), for the licensed users.[4]

Another important data for a realistic analysis and modelling is the tour-based (activity-based) freight data, which is currently lacking in the SMVU and the FMS conducted by ABS. As far as we are aware,

[4] http://www.abs.gov.au/websitedbs/censushome.nsf/home/tablebuilder

a tour-based questionnaire was designed by ABS as a part of SMVU in 2014 and sent out to a smaller sample. However, due to the limited sample size, no data was reported.

Notably, the ABS data are limited to the road freight task since the ABS ceased collecting rail, sea and air data after 2001. Accordingly, the ABS released the last dataset in 2001 for other transport modes (rail, sea and air) which were collected in 1996 (ABS, 2002), where the road component was also suspended due to data quality problems.

BITRE as another main organisation responsible for data collection, analysis, and dissemination, also provides a summary of freight statistics in the Australian Infrastructure Statistics Yearbook regularly. The latest published in BITRE (2018f), classified the freight task by mode of transport, and freight is further classified into bulk and non–bulk. Two measures of freight transport are currently provided in these reports:

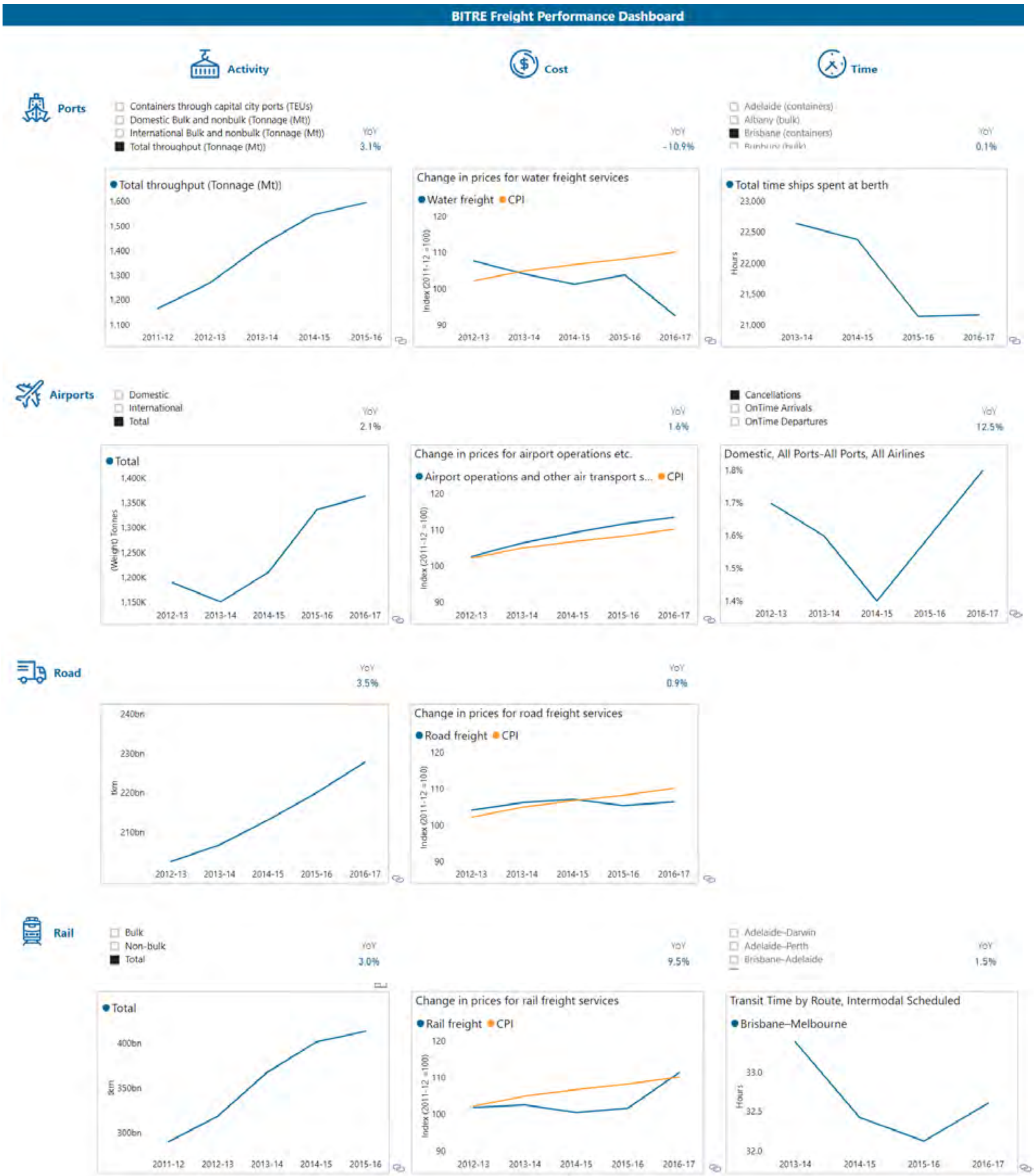
1. the weight of freight moved in Australia (measured in millions of tonnes); and
2. freight by weight and distance moved (measured in tonne-kilometres— the transport task performed in moving one tonne of freight one kilometre).

In BITRE (2018f) the following datasets are provided, supplemented by other sources such as the SMVU and RSFM by the ABS:

- Domestic freight, by transport mode—bulk and non–bulk (billion tonne-kilometres);
- Total domestic freight by state/territory, by transport mode—road (billion tonne-kilometres);
- Intrastate and Interstate freight by state/territory, by transport mode—road (billion tonne-kilometres);
- Urban road freight by the capital city (billion tonne-kilometres);
- Total vehicle kilometres travelled, by vehicle type, Total vehicle kilometres travelled, by vehicle type, by state/territory; and
- Total road freight, by vehicle type.

BITRE (2014b) also provided actual domestic freight volumes for 2011–12 and projected domestic freight task for 2040. In addition to the aforementioned reports, BITRE publishes reports about road freight task, providing the time-series data and analysis (eg. (BITRE, 2010b; BITRE, 2015b)), and also provides an online dashboard to show the movement of road freight and changes in prices for the road freight services, as shown in Figure 3-1 (BITRE, 2017a).

Figure 3-1. BITRE freight performance dashboard



3.1.2 Rail freight task

Trainline reports published by BITRE are the main source providing rail freight task (BITRE, 2012a; BITRE, 2014d; BITRE, 2015c; BITRE, 2016; BITRE, 2017b). In the latest published report by BITRE (2017c), the total national rail freight task is estimated using the aggregated data provided by rail train operators namely Pacific National, Aurizon, Fortescue Metal Group, BHP Billiton, Rio Tinto, Ray Hill Holdings, Genesee & Wyoming Australia (including Frightliners), SCT Logistics, TasRail, QUBE, Watco, and Fletcher International Exports.

The ‘Interstate Network Traffic Report’ is another source providing data on the interstate freight task, the growth rate of the freight task in Australia in 56 origin destination (ODs), as well as the intermodal task per line segment (BITRE, 2012). This report presents interstate traffic flows by line segment based on ‘below rail’ (track infrastructure manager) provided data. It only includes tonnages on the interstate network that the Australian Rail Track Corporation (ARTC) and ARC Infrastructure (formerly Brookfield rail) manages. This data also shows growth of gross tonnage by line segments from 2013-14 to 2015-16, and provides a summary of the rules used in assigning freight to six line segments.

It should be noted that the rail freight task by line segment refers to interstate freight only. Intrastate freight is not assigned to a line segment as data from above-rail train operators do not distinguish on which line freight is being hauled. The inter-capital city line segment share is given by net tonne-kilometres (NTK) of city pair origin-destination intermodal and non-intermodal rail freight divided by the total rail freight task for the line segment. BITRE’s estimates of the inter-capital city line segment task is based on data from below-rail infrastructure managers and above-rail train operators on inter-capital city freight hauled.

Traffic volumes (in terms of tonnes, NTKs, and TEUs) reported in (BITRE, 2012b) reflect rail’s competitiveness with other transport modes (particularly for intermodal traffic) and prevailing economic conditions. The freight task, as reported by ‘hire-and-reward’ and ancillary railway operators also has been reported by ACG (2007).

3.1.3 Shipping freight task

The ‘Waterline’ series published by BITRE reports on trends in throughput, container handling productivity on the waterfront and the land side of ports, and the cost of importing and exporting containers via five container ports. It covers both the loading and unloading of container ships and the transport of containers from container terminals (BITRE, 2018a).

The Waterline series published before 2016, also presents data about Australia’s international exports and imports by sea from 2006–07 to 2015–16, including the value and weight of exports and imports by Australian state/territory, major Australian ports, and by different trading regions and major trading partner countries (BITRE, 2018f). Additionally, trade statistics for all ports in Australia for the main commodities and containerised for 2014-2015 can be found in a table format published by Ports Australia (2015).

Measures of container terminal throughput (BITRE, 2018b) are mainly provided in the Waterline series, which also provides information on container movements on both the wharf-side and the landside of five Australian major port terminals: Brisbane, Sydney, Melbourne, Adelaide and Fremantle. For these ports, the data is collected from these terminals, and by the relevant authorities (DP World, Patrick, Hutchison Ports Australia, Flinders Adelaide Container Terminal, Victoria International Container Terminal, Port of Brisbane Pty Ltd, Maritime Safety Queensland, Port Authority of New South).

Waterline presents all container port throughput indicators in a consolidated format. Indicators are presented separately for Brisbane, Sydney, Melbourne, Adelaide and Fremantle, as well as for the five ports as a whole, where applicable. The indicators are in four groups: (i) wharf-side, (ii) landside, (iii) whole of container terminal, and (iv) whole of port. Measures of container terminal productivity are also reported in three groups: (i) wharf-side, (ii) landside, and (iii) whole of container terminal.

Statistics on international shipping container movements were also collected in 2009-10 for the five major ports by ABS (ABS, 2011a, ABS, 2011b). The statistics include the number of inward international container movements, by Six Digit Harmonised System Number and by Delivery Postcodes.

BITRE (BITRE, 2018d) also provides statistics about the coastal freight through Australian ports between 2006–07 and 2015–16. The weight of coastal freight has been derived from data supplied by port authorities in response to BITRE's annual 'Coastal Freight Survey'. It worth mentioning that the coastal statistics provided by port authorities on weight loaded and discharged do not always balance for a few reasons (eg. being in transit during the cut off period, limited knowledge about the origin, destination by the ship's agent, and the difference in commodity classification. However, BITRE has reconciled some of these problems by matching corresponding loaded and discharged records and, where possible, by comparing to records in the Coastal Trading Licensing System (CTLS, maintained by DIRDC).[5] Notably, caution should be taken when comparing shipping activity recorded under the previous (2002–03 to 2011–12) permits system and voyages under temporary licence (2012–13 to 2015–16), due to differences between the two systems.[6]

Furthermore, there are dispersed data points provided at the state level, for example, the Queensland Ports Trade Statistics Report 2017 by the Department of Transport and Main Roads (TMR, 2018g). This report has been produced based on information sourced from port corporations' and trade organisations' annual reports and other industry-related material and includes Port of Brisbane, Gladstone Ports Corporation Limited, North Queensland Bulk Ports Corporation Limited, Port of Townsville, Far North Queensland Ports Corporation Limited (trading as Ports North).

3.1.4 Air freight task

There is siloed information from which the air freight task can be directly or indirectly derived. BITRE (2013) presents domestic freight movements (tonnes), aircraft movements (all aircraft), and monthly airport traffic data for the top twenty airports: January 1985 to 2013.

BITRE (2018a) publishes airport traffic data from 1985–86 to 2017–18(with Regional airline split) where freight carried by top five airlines, and freight carried on the top five city pairs are reported. BITRE has taken due care in preparing this information. However, data has been provided by third parties, and have limitations such as inconsistent figures for airports and airlines. For example, it is likely that the starting point for some recorded data reflects new responses from airlines at one point in time rather than the actual starting date of the time series. For example, airlines such as Fly Tiwi,

[5] Department of Infrastructure, Regional Development and Cities (DIRDC), 2017. Coastal Trading Licensing System (unpublished data), Canberra.

[6] Up to 2011–12, permit holders who carried out container shipments reported both the number of TEUs shipped and the weight of the TEUs. Under the new system temporary license holders record in CTLS either the number of TEUs or the weight of cargo shipped (not both).

Hinterland and West Wing only started to provide data to Aviation Statistics Section from 2009. However, it is likely that some of these airlines have been providing air services to regional areas prior to the data collection date. Hence, in some cases, the starting point of a data series may not represent the actual commencement date of the data series.

Imports and exports by air have also been reported by MariTrade (2018) including information on overall weight and value into two categories (perishable and non-perishable) for Brisbane, Melbourne, Perth, and Sydney airports.

Notably, approximately 90% of air freight is carried in the cargo holds of passenger flights. Accordingly, it is problematic to derive the correct figure of air freight task. While the volume is lower compared to other modes, it makes a significant contribution to the economy due to the high value of the items contained because goods transported by air are typically characterised as high value, time-sensitive and perishable.

3.1.5 Commodity-based freight task

The 'Freightline' series published by BITRE presents the size, scope and location of some important commodities freight movements in Australia, and provided actual estimates of domestic freight volumes for 2011–12. These series include freight task on iron ore (BITRE, 2014c), sugar (BITRE, 2015a), coal (BITRE, 2018e), and rice (BITRE, 2018c).

3.1.6 State-based freight task

Apart from national reports on freight transport tasks, state governments also separately report information such as the freight task for Victoria (DEDJTR, 2018), NSW (TfNSW, 2018), Queensland (TMR, 2013), Western Australia(WA Government, 2011), and Tasmania (TAS Government, 2017). While the original source of this information is not clear, it is assumed that the basis of data is either ABS microdata and/or other state-based surveys and data collections.

3.1.7 Modal shift

From time to time, a particular freight task emerges that lends itself to a less traditional solution than usually associated with road and rail. For example, coastal shipping is used for long distances between dispersed locations, or river barges for transporting heavy equipment.[7] Furthermore, despite the existing challenges that potential coastal freight shipping services may face, the freight and logistics industry is interested in assessing the potential demand for this mode as an alternative to road and rail transport. Provided that freight shipping can secure sufficient demand for coastal shipping, the industry should be able to use the data of trade-off of cost and benefits and challenge coastal trade regulations overseen by the federal Government.

The coastal shipping market share in Australia currently accounts for about 17% of the total domestic freight movement with a decreasing trend (Australian Government, 2015). While this finding is not supported empirically (Helen B. Bendall, 2011), it is believed in the Australian context that coastal shipping is competitive in corridors exceeding 2,200 km, while road transport leads the market for

[7] Barges are still used in parts of Australia to move heavy or over dimensional equipment such as power transformers.

distances up to 1,500 km and rail transport dominates corridors between 1,500 and 2,200 km (Australian Government, 2006). Mode choices of Australian freight shippers are seldom an all-or-nothing decision but rather involve timing, interoperability and risk considerations through route and mode allocation (Brooks et al., 2012).

Coastal shipping is mainly a service offered by ships under foreign flags. There remains a demand for coastal shipping among dispersed locations. For example, the transport of bauxite between Weipa and Gladstone in Queensland alone accounted for about 30% of the total Australian domestic sea freight in 2011 (PBPL, 2013). As such, coastal shipping can be considered to be an alternative option for moving of bulk commodities over the long distances.

The limited uptake of coastal freight shipping in Queensland (and Australia-wide) is also attributed to the existing coastal trade regulations. Australia's coastal trade regulations (Navigation Act 1912) limit access to national ship operators or national flag vessels with national crews (Webb, 2004), known as cabotage. The existing regulations provide that ships licensed to operate in coastal trade, among other things, must pay applicable Australian wages. Cabotage is a form of protection for Australian-registered ships. From an economic perspective, cabotage increases the freight transport cost when operated by a national crew. However, given the high level of competition in the freight and logistics industry, cabotage places national ship operators in a disadvantaged position compared to foreign-flag and foreign-crewed competitors (Webb, 2004).

Despite the existing challenges that potential coastal freight shipping services may face, the freight and logistics industry has shown interest in assessing the potential demand for this mode as an alternative to road and rail transport. Provided that sufficient demand existed for coastal shipping, the industry would be able to use this finding and challenge coastal trade regulations ruled by Australian federal government.

While a previous analysis of three national freight corridors (Perth-Melbourne, Melbourne-Brisbane, and Brisbane-Townsville) suggested that coastal shipping could be considered in light of reduced transit time and increased reliability that mitigates the risk of delay (Brooks et al., 2012). A study by Schrobback et al. (2019) overcomes the aggregate level of that study by looking specifically at the potential demand for coastal non-bulk freight shipping within the Brisbane-Townsville corridoor by undertaking a stated preference survey. This study revealed that about 30% of the 64 company representatives chose a coastal shipping option. Model estimates revealed a 'willingness to pay' of about AUD$20 per hour for saving one hour of transit time in the corridor, a higher direct elasticity for road transport with respect to cost, a higher direct elasticity for sea transport with respect to time, and an effect of road user charge on shifting from road transport. Interestingly, model estimates showed the tendency of half of the sample to ignore either transport or cost (if not both) in their mode choice decisions, and in this case the willingness to pay increased to about AUD$30-44 per hour for decision-makers not ignoring time and cost in their decisions.

3.1.8 Limitations and gaps in data on the freight task

We have identified a number of limitations and gaps from the review of the existing data on the freight task, which are outlined as follows:

1. Siloed and non-harmonised freight task data make the analysis and interpretation difficult. For example, BITRE publishes separate reports, namely the Freightline report series for road, the TrainLine report series for rail, and the Waterline report series for shipping, while very similar data are provided by other entities such as the ACCC, and state governments.

2. Inconsistencies in the published data for freight tasks across various transport modes and outdated data for rail and air freight limit the analysis of the freight task overall. For example, in the BITRE 2018 yearbook (BITRE 2018f), information on the road freight task is relatively up-to-date, compared to shipping and rail freight data, which is published to 2009-10.

3. Much of the data published is too highly aggregated. The granularity of the SMVU is not sufficient for modelling purposes (the most disaggregated level available is at the SA3 level). The inter-state and intra-state rail freight task published in the Trainline series (eg. (BITRE, 2017c)) is also published in an aggregated format.

4. Data is not collated sufficiently frequently. For instance, the RFMS is not conducted on a regular basis (the latest data was collected in 2014) and is limited to only a sample of articulated and rigid trucks.

5. It is often not possible to link individual data sources. For instance, it is not possible to link the SMVU and the RSFM to determine the share of agricultural commodities transported by refrigerated semi-trailer from one origin to destination or the average payload.

6. There are numerous issues around the SMVU. For instance:

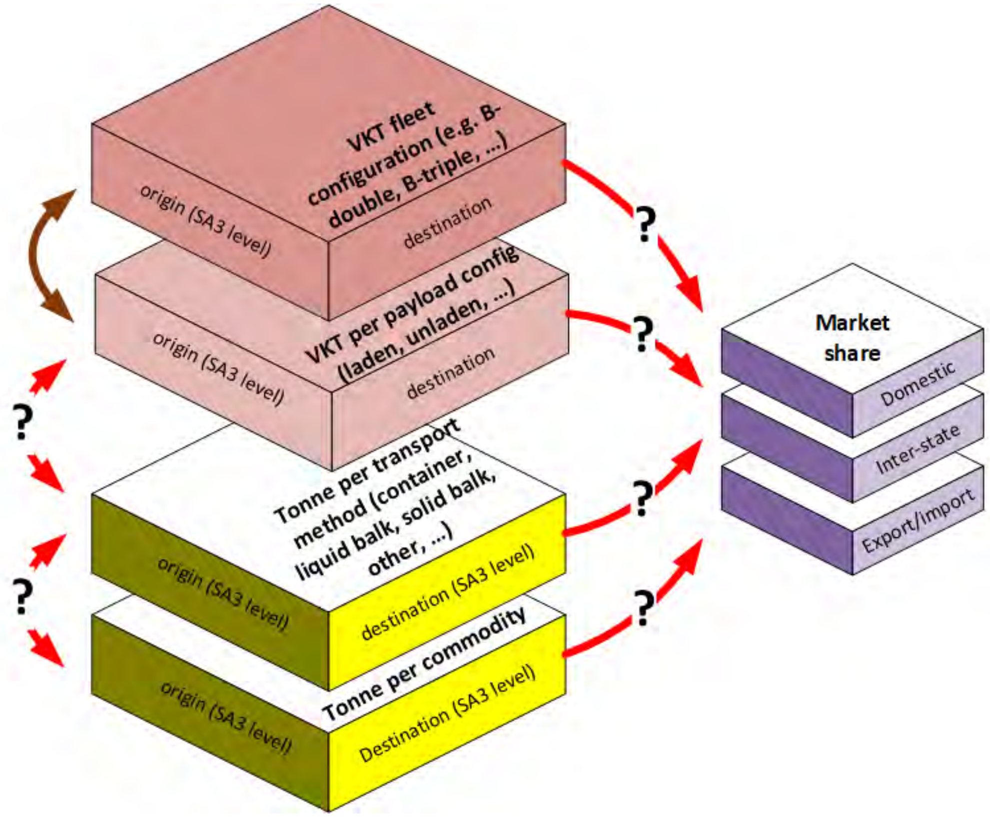
    - The SMVU provides no information on the share of domestic, intrastate, inter-state and international market from the road freight tasks.

    - It is hard to derive the tonnage of agricultural commodities transported from one specific origin to be consumed in the domestic market in a specific destination (Figure 3-2).

    - The SMVU also does not include the freight task information separately for ancillary or for-hire operators.

    - The SMVU does not contain information on trip legs, for example, the number of stops, and payload on each leg of the trip.

Figure 3-2. Lack of linkage between information from SMVU, published by ABS



7. There are questions about the extent of quality controls and the accuracy of data, perhaps because erroneous data were reported or entered incorrectly. For example, it appears that some airlines might have reported chartered or cargo services as regular public transport air services.

8. There is no data on domestic rail freight task broken down by commodity type (eg. agricultural) or on a corridor level.

9. With the majority of air freight is being carried in the cargo hold of passenger aircraft (90%), supported by some dedicated freighters, the inability to separate passenger flights and freight flights makes understanding the air freight task difficult.

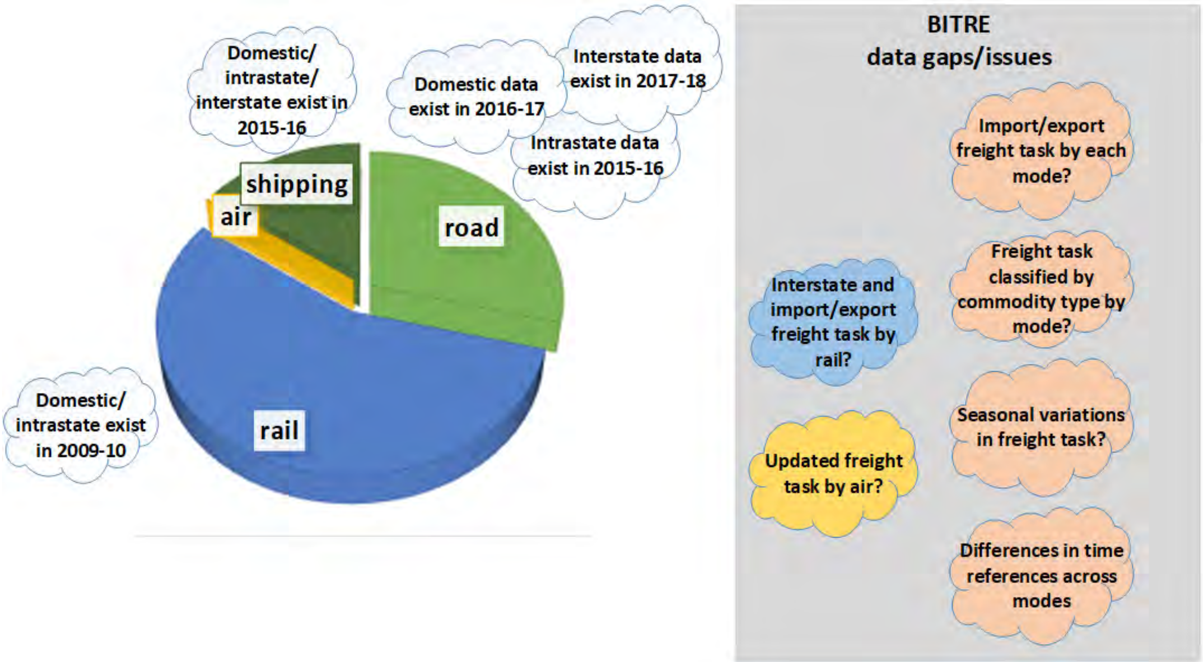
10. There is a need for clearer documentation of sampling, modelling and estimation procedures on the parts of the ABS, BITRE and state governments, in order to clarify how data were collected and what the limitations are.

11. There are no consistent annual reports on specific freight tasks, nor is there information on seasonal variations. The few existing studies on the freight task for commodities such as rice (BITRE, 2018c) or cotton (BITRE, 2018e) were done on a one-off basis only. The estimates, do

not account for the variations in movements across different years, nor consider seasonal variations.[8]

12. There is a need for further surveys and studies about factors and attributes of transport mode choice and modal shift behaviours among the freight operators.

Figure 3-3. Data gaps and issues with freight task published in infrastructure yearbook by BITRE

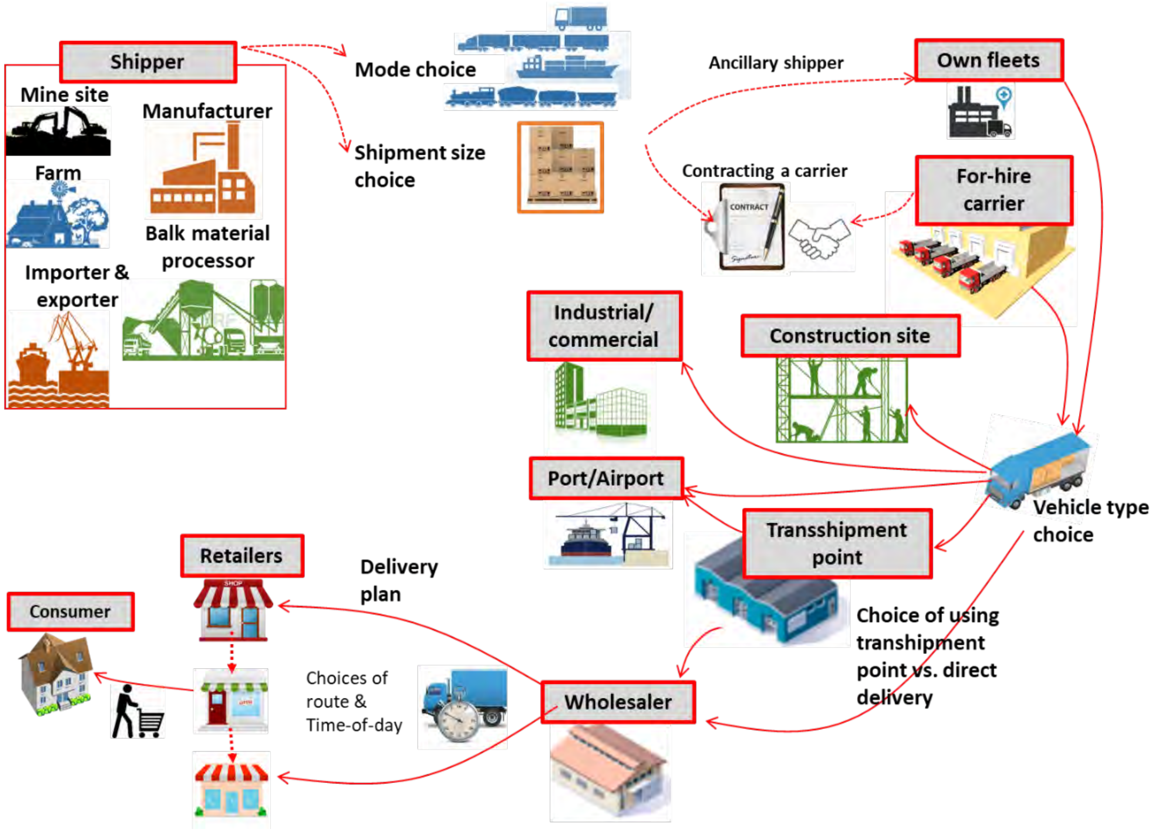


3.2 Supply chain visibility of commodities

The supply chain is a result of nodal and modal activities as shown in Figure 3-4, where modal activity includes the preferred mode of transport for each shipment based on the commodity type, size (weight and dimension), and other specifications such as the time at which a pick-up or delivery is made (often referred to as time windows). Nodal activity refers to the location where key activities occur, including origins (pick-ups), destinations (deliveries), and intermediate locations (transhipment) used for distribution, consolidation, and storage. Supply chain visibility means the availability and visibility of information across these nodal and modal activities.

[8] For example, a major issue impacting cotton transport arrangements is the seasonal nature of cotton transport and inter-seasonal variability. As an annual summer crop, demand for cotton transport services peak from March to May. During this time, the cotton is picked and transported to gins for processing before being transported to ports for sale and export. Seasonal variation in cotton freight volumes also affects the nature of the cotton freight task. Cotton production varies from year to year depending on environmental factors such as drought.

Figure 3-4. Supply chain elements (Irannezhad, 2018)



Undoubtedly, the essence of this nodal and modal co-ordination in the supply chain is information about each element and how those elements interact. Without an understanding of the capacity of the entire supply chain, it is extremely difficult to know where the capacity constraints are likely to emerge and how they should be addressed. Accordingly, imperfect information is one of the key causes of supply chain coordination failure. Particularly given the number and complexity of the freight supply chain, the unimpeded flow of information is essential to function efficiently and for each participant to be accountable for its performance.

3.2.1 Existing information about the supply chain

Information about the supply chain for four main commodities only limits to Freightline publications, published by BITRE for only four major commodities (iron ore, sugar, cotton, and rice), and a few one-off data points provided by different departments or private entities, such as a series of publications by QTLC, the Tasmanian (2017), or Aurecon (2013), , as presented in Table 2.

Table 1-1: Supply chain studies in Queensland

PRODUCTS	KEY NODAL INFRASTRUCTURE	RESOURCE
HORTICULTURAL PRODUCTS	Farms and areas of production rural consolidation hubs ripening and pre-packing facilities food processing facilities produce markets, usually being one main market in each state with some smaller regional markets • FMCG distribution centres.	(QTLC, 2013d)

PRODUCTS	KEY NODAL INFRASTRUCTURE	RESOURCE
LIVESTOCK AND MEAT	stations and grazing lands cattle dip and inspection stations (31 throughout Queensland) sale yards feedlots abattoirs meat processors FMCG distribution centres • Butchers and independent retailers	(QTLC, 2013e)
COTTON	farm to gin gin to warehouse/ processor/ export/ feedlot • Warehouse/ processor to domestic and export manufacturers and spinners.	(QTLC, 2013a)
FAST MOVING CONSUMER GOODS (FMCG)	import product arrives at ports and/or moves on to local value adding or processing steps the vast majority of the volume is directed to distribution centres, with some direct-to-store deliveries individual store orders for delivery are dispatched from distribution centres either by road or to rail intermodal terminals • delivery is made to stores	(QTLC, 2013b)
FUEL	ports, including harbours, berths and fuel unloading, storage and loading facilities refineries for domestic production of refined products terminals (at port and refinery), for both road and rail distribution regional depots, for intermediate storage service stations and retail outlets • private fuel farms, for major industrial and agricultural producers	(QTLC, 2013c)
SUGAR	• farms • cane load and transfer points: farm to rail, farm to road • mills • refineries • ports, harbours, berths and bulk sugar handling equipment • food manufacturing facilities • Fast-moving consumer goods (FMCG) distribution facilities.	(QTLC, 2013h)
PROJECTS & CONSTRUCTION	Ports Quarries water sources concrete batching plants hardware supply points and distribution centres fabrication and manufacturing operations industrial estates	(QTLC, 2013g)5
OVER-SIZE OVER MASS (OSOM) (THESE VEHICLES MOVEMENT ARE IMPORTANT TO TRANSPORT INFRASTRUCTURE)	origin of transport equipment origin of load facility infrastructure capacity on the route (structures and pavement) rest stops on route decoupling yards on route refueling stations on route passing lanes on route destination of load facility • destination of transport equipment	(QTLC, 2013f)

TraNSIT, provided by CSIRO, is an outstanding example of a supply chain visibility tool, that supports analysis of infrastructure investments in our agricultural supply chains. While it began with beef in Northern Australia, the tool is currently being applied to broader Australia-wide agriculture transport, comprising more than 25 commodities. Now it includes information on the transportation of cattle as well as grains, dairy, poultry, rice, cotton, pigs, sugar, horticulture crops and stock feed. Forestry and sheep will be added in the near future. The tool considers transport from farms to storage, feedlots, processing, export ports, as well as domestic supply chains to distribution centres and retailers. It can be used to manage logistics costs for individual enterprises or whole industries and could be easily extended beyond agriculture and forestry to accommodate other freight.

In another practice, NTC (2017) identified the lack of availability of data on commodities arriving into and leaving Australian ports, notwithstanding the fact that DIBP's Integrated Cargo System (ICS) should have this data. As an outcome of that project, the NTC continued working with DIBP at officer level to agree on data fields and a report template to be provided to the NTC on a quarterly basis. As there is nothing in the data that identifies individuals or companies, NTC is also able to provide access to jurisdictions for their analysis purposes. To do this, the NTC has established a cloud-based solution where all jurisdictions are able to access and download the data. This is a major step forward and will contribute to the evidence base for transport and related decisions made across the country in future. For example, the import data can tell us that four horses were imported via air to Sydney and delivered to Bathurst. They weighed 2,216kg and were valued by the importer at AUD$29,900. What it can't tell us is where the horses originated overseas, and the mode of transport used to deliver the horses from Sydney to Bathurst.

The export data can tell us for example that 68.25kg of men's clothing, with a value of $2,099 was manufactured in New South Wales and exported by air from Sydney to Canada. The exporting business is based in outer Sydney. We can now see this information for all commodities imported to and exported from Australian air and seaports, giving transport planners unprecedented ability to understand commodity movements and values. The first report was provided for the January – March 2017 quarter. The NTC has developed a SharePoint site where jurisdictions are able to access and download the reports for their own analysis purposes each quarter. Already, the CSIRO has been able to produce some sample freight flow maps utilising the data.

In order to examine the consistency of ICS data and other open data provided by other government agencies, we undertook a case study comparing the data of ICS (permission-based dataset), the results of exporter interviews in a study by SCU (2018), and freight import/export data of NSW Strategic Freight Models, and Survey of Motor Vehicle Use (SMVU).

Freight import/export data of NSW Strategic Freight Model (SFM), released in October 2018 as an open data, has used SMVU survey of 2016 by (ABS, 2017a) as one input to estimate various commodity type tasks per mode into three categories: intrastate, interstate, and import/export. SMVU is also reported in the more disaggregated statistical analysis level (SA3 level) as a Microdata (Table Builder platform) under the license from which the tonnage originated/destined from/to port locations can be extracted and a share of those amount can be assumed to belong to import/export task. In our case study, SFM presents only 61.26 kilo-tonne of beef originated from Richmond Valley hinterland (origin) as export to the Port of Brisbane. However, ICS data for six months (January – June 2017), represents the significant tonnage of export of live animals and beef originated from the region and exported through the Port of Brisbane, and not any other commodities. While the lack of data about live animal exports in the SFM and ABS is inconsistent with the ICS data, the lack of agricultural and manufactured food export in SFM, SMVU, and ICS datasets are also inconsistent with the Customs data and the exporter's interviews. Accordingly, we argue that the integration of ICS data with the state-based freight models and SMVU can be a huge benefit for the transport modellers and planners and decision-makers as a result of producing more robust models.

Lastly, there are dispersed reports about the origin-destination of various commodities across states such as:

- Geraldton Port Authority (2013): origin-destination of cargo at the Geraldton Port in Western Australia;
- TfNSW (2018): origin-destination of the products in NSW;
- ABARES (2016b): origin-destination of Australian forest and wood products;
- BITRE (2018d): origin-destination of the Australian sea freight;
- DNRME (2017) and NSW Mineral Council (2012): origin-destination of mining products for QLD and NSW;
- ABARES (2018c): origin-destination of agricultural commodities;
- ABARES (2018b): origin-destination of some commodities such as coarse grains, wheat, wool, horticulture, cotton, dairy products, forestry commodities, fisheries, food, meat (general, beef and veal, pigs and poultry, sheep) and wine;
- ABARES (2015): origin-destination of wheat including export destinations;
- ABARES (2016a): origin-destination of Australian fisheries and aquaculture, without any information about the mode;
- DEDJTR (2017): origin-destination of food and fibre products;
- DNRME (2018): origin-destination of pastoralists with a means of moving stock 'on the hoof' around the state's main pastoral districts, as an alternative to trucking and other contemporary transport methods in Queensland; and
- RMS (2018b): information about the Livestock Loading Scheme including b-double and a-double network and Livestock Loading Scheme map. This data helps the visibility of the supply chain of livestock.

These datasets, however, do not provide detailed information about the supply chain, neither the mode or means of transport.

3.2.2 Limitations and gaps

The invisibility of the supply chain will lead to misunderstanding of the size and scope of the Australian freight task. While there are outstanding reports and practices to provide supply chain visibility in Australia, a few limitations also arise from this review as:

1. With supply chain practices being different across states, supply chain should be mapped across all states in a consistent and harmonised way enabling comparison between different supply chain performance and efficiencies.
2. Successful practices such as TraNSIT can be applied to other supply chains.

3.3 Integrated coordination schemes

While billions of dollars are spent on infrastructure to move freight more efficiently, the complexity of the freight market and the lack of collaboration between the various agents in this market often lead to sub-optimal use of that infrastructure. For example, the mismatch between working hours of freight operators in the import/export supply chain results in a long queue of trucks at the container terminals during peak hour and unutilised capacity of stevedores during after-hours period. A case study by Fremantle Ports (2014) showed that transport operators have achieved success as coordination with importers through the extended operating hours and off-peak delivery by having after-hours access to importer premises using keys and access codes. However, such coordination schemes are not a usual practice in Australia.

Inefficiencies are exacerbated where participants are operating as silos in the supply chain with a limited sense of common purpose or the impact of each element on the overall performance of the supply chain. For example, according to Fremantle Ports (2014), the import/export balance is a critical factor in a carrier’s ability to undertake two-way truck loading to and from a container terminal. It also affects how fleets are managed. Two-way capability, truck utilisation and empty running of trucks are key indicators of the productivity levels of the industry. A case study by Fremantle Ports (2014) showed that transport operators have achieved success as coordination with importers through the extended operating hours and off-peak delivery by having after-hours access to importer premises using keys and access codes.

The service providers in the supply chain all ultimately depend on the accurate information regarding expected throughput. This is necessary for scheduling and day to day operations, as well as capacity forecasting and planning. Information also needs to be exchanged between importers/exporters, truck operators, above-rail owners/operators, below-rail network owner/operators, shipping and the port terminal operator. Where the supply chain consists of a number of different members, information is dispersed and needs to be able to be coalesced to facilitate planning and operations.

Information exchange and coordination can be provided through an online marketplace where visibility, tracking and traceability are highly maintained. Such a marketplace, when developed, can become a key piece of the port infrastructure where the associated costs of each actor in each segment of the chain are shared. Accordingly, the visibility of the supply chain and the costs for every actor in the coordination scheme can be enhanced by using unique digital identifiers (electronic data interchange, EDI) for inter-organisational transactions across the chain. Automation, integration, operation, and maintenance of the system, however, comes at a cost for port authorities. However, facilitating the supply chain and increasing the efficiency of all actors is not only a driver of port competitiveness but also a driver of economic growth by empowering local businesses (Irannezhad et al., 2018).

Horizontal and vertical supply chain integration schemes supported by the governments not only provide a trusted platform for private businesses to exchange the information and facilitating their operation but also is act as a tool to provide freight data for planners and policymakers. For example, initiatives such as Port Community System (PCS) works with several stakeholders to maximise use of existing network capacity and improving the efficiency of cargo movements. It is a platform where everyone involved in international trade can securely share their information with their business partners across the supply chain to drive productivity through a trusted and multi-level data access architecture. PCS enables stakeholders managing the information regarding one shipment in one place, managing ocean and road bookings, and see container and customs information, as well as visibility on route status including split routes and transhipment ports. Rather than integration, optimised logistics solution as value-added services can be provided to the businesses such as truck-sharing, back-loading (also known as backhauling), street-turn strategy (empty container swapping between importer and exporter).

According to Irannezhad et al. (2018), a focus group of freight operators located within the Port of Brisbane precinct revealed that each company has a well defined empirical procedure to optimise their resources and will occasionally cooperate with others to meet their demands, but there exists a lack of integrated tools and systematic cooperation across companies. The inefficiencies mentioned above happen largely because of incompatible interfaces between the actors, the reliance on manual transactions, and the lack of interoperability between their systems. For example, the focus group showed that currently, bilateral communication between parties occurs mostly with email communication, and on some occasions with dedicated user interfaces (eg., 1-stop). However, all parties were in favour of linking up one single interface in order to reduce their manual work and human errors. This study simulated the benefits of street-turn strategy and cooperation through such an integrated platform, while another study by Irannezhad et al. (2017) also revealed that the savings in logistics costs in cooperation are generally higher for operators who have fewer shipments to deliver, while cooperation sometimes imposes a higher logistics cost upon the major operators.

While individual companies use the latest technologies to monitor the performance of their fleets and firms, they have not been willing to pass on data unless they see the benefit for their operations. This situation, however, can gradually change, and private businesses will advocate sharing data if they see their data is utilised for their needs, to support investments and reforms. Understanding the needs of users, measuring the performance of the freight and logistics system and improving accountability for delivering changes are essential to developing a high performing freight and logistics system and planning for a more prosperous future, and it is not obtained unless under coordination and integration of all stakeholders.

3.3.1 Existing integrated coordination schemes

The existing coordination schemes are mainly focused on import/export international trade. 1-stop is one such scheme. It is an online portal allowing users to submit Pre-Receival Advices (PRAs), access live vessel schedules, book a timeslot at the stevedores, and track containers in real time. However, neither port authorities nor operators have access to the detailed recorded information. Furthermore, it has not been integrated with the empty container parks, exporters, importers and customs, and is used only by stevedores, trucking companies to book the timeslots at the wharf.

Cargo Management Co-ordination Centre (CMCC), or CMCC, was established in NSW in 2014 as a coordination scheme between road carriers, rail operators, stevedores, and related supply chain stakeholders. The CMCC focuses on key Port Botany and Port Kembla, road, rail and intermodal terminals in regional NSW for bulk commodities. The CMCC scheme includes truck marshalling area, the Port Botany Data Performance Data Mobile App and the establishment of the Port Botany Rail Optimisation Group. The Port Botany Rail Optimisation provides a forum for rail stakeholders to identify options to improve the efficiency of rail movements at Port Botany working collaboratively with industry and enables them to have better visibility of available capacity in the network to boost efficiency.

Trade Community System was also showcased by the Port of Brisbane, Australian Chamber of Commerce, and PWC in June 2018, and is seeking a pilot funding.

The secondary uses of road telematics data is another example of the benefits of big digitised data. A product of the Intelligent Access Program (IAP) as the first example of the use of telematics within the regulatory framework for managing heavy vehicles in Australia, has included a large GPS dataset since 2011. Once a transport operator has enrolled in the IAP, the vehicle is assigned a telematics 'black box' (In-Vehicle Unit or IVU) and a Self-Declaration Input Device (SDID). The IVU and SDID gather data from the vehicle and return it to the IAP for monitoring. The IVU is installed in the prime mover and monitors that vehicle in isolation – it cannot be associated with more than one vehicle or switched between two vehicles. The incentive for freight operators to participate in this plan is to receive improved access to particular roads in exchange for compliance. This program has demonstrated an increasing number of enrolments of freight operators during the last seven years, opting in to benefit from this incentive.

Although this programme aims to assure road authorities that heavy vehicles operating under the programme are compliant with the appropriate conditions, there are several practical implications for policymakers arising from this granular dataset. Hence, exploring the existing datasets and designing possible incentivised programs is important to tackle.

According to ALC (2018c), ALC members have been cooperating with BITRE and the ABS since 2016 to develop experimental indicators derived from IAP programme for:

- Congested freight-significant network locations;
- Average travel speed of freight vehicles;
- Routes taken by freight vehicles;

- Origin and destination of freight vehicle movements; and
- Freight vehicle stop locations and durations.

The intention is to identify congested networks, key freight routes and average travel speed and travel times on key freight routes. Other outputs developed would include where, when and for how long freight vehicles are stopping and the amount of road freight activity. Government agencies are now looking at increasing the number of freight service providers involved in developing this project. ALC (2018c) recommended that ALC encourages continued industry participation and government commitment to the Road Freight Telematics Data Collection Project to ensure that this important data can be used by industry to enhance efficiency and safety.

Undoubtedly, technology adoption by the industry and harmonisation and standardisation schemes such as GS1, IAP will pave the road for Integration schemes such as TCE.

3.3.2 Opportunities and future technological trends

With the technological trends under the headings of big data, electrification, digitalisation, automation, integration and blockchain, there should be detailed data on the impacts of technological adoption and the cost-benefit analysis for various sizes of industry under these headings. While it has been expected that for example e-commerce impacts fleet share of different fleet configurations in road sector, or the performance metrics hugely impacted by introducing the automated stacking cranes and automated guided vehicles (AGVs) in container terminals, government would better to take a central role to support, monitor, and integrate these technological schemes.

Currently, the information systems supporting supply chains reside with the individual supply chain participants, and are based on various barcodes or tracking IDs. Some of the shortcomings of the current systems could be overcome by the application of blockchain technology which effectively digitises all transactions. This holds the prospect of improved accessibility and readability. The use of blockchain can help particularly on shipments or freight with digital identifiers such as containers. It not only improves the process coordination by increasing knowledge and mutual information sharing among the stakeholders but also increases the security of physical flows by encryption of transactions. Enabling smart contract increases the gains from contractual trade, reducing the size of companies, paper-based and manual works, and increasing economic outputs through a more efficient system. This technology can overcome international trade hurdles and disputes among agents over unexpected costs incurred by digitising peer-to-peer collaboration tools and payments. Although track and traceability can be provided by digital identifiers and universal product codes, the immutability of blockchain plays an important role in guaranteeing the validity of those identifiers to all parties (Irannezhad, 2019).

Another example of recent technological change in the freight transport and logistics sector is the introduction of automated stacking cranes and automated guided vehicles (AGVs) at our ports. These machines increase the container handling efficiency on the wharf. Their first use in Australia was at the Port of Brisbane and they and have now been introduced at several other ports. Further technical evolutions currently in progress include 'virtual' or 'remote' piloting, and ultimately autonomous ships. For the rail sector, Deloitte (2017) highlights the transition to autonomous driving technology as a significant opportunity for the rail sector as driverless technology offers the potential to achieve greater efficiency in operations. However, this report also mentions that implementing driverless technology in the rail sector is challenging as it requires improvements to signalling and communications infrastructure. The forecast of autonomous systems and vehicles is expected to have significant effects on the workforce, and as these systems get deployed, they will require new workforce skills in technology, remote operations, diagnostics, maintenance and communications.

Lastly, e-commerce is also impacting the freight community. As the volume of e-commerce transactions grows, so too does the fulfilment task. For example, Australia Post saw a 5.6 per cent rise in domestic parcel volumes in 2016-17 as result of e-commerce growth. This volume growth, combined with increasing customer expectations for rapid delivery, is not just increasing the delivery traffic but it is also changing the configuration of our delivery fleet. This trend is reflected in Victoria's vehicle registration data, where the growth in LCV or 'small white vans' has outstripped the growth in other freight vehicles in recent years, (DEDJTR, 2018).

To sum up, the take up of new technologies can have a significant positive impact on the productivity and efficiency of freight operations.[9] Accordingly, strategic plans should carefully consider the opportunities provided by technological change and innovation in the freight supply chain industry.

3.4 Data on productivity and performance measures

According to BITRE (2011), Productivity measures the quantity of outputs per unit of input as either partial or single factor. For example, labour productivity measures the amount of output produced per unit of labour input for an industry or single firm, producing a single product. Partial productivity measures can be derived for each physical input. In the transport sector, for example, productivity could be defined per unit of labour, capital, fuel or other input factor. For example, in BITRE reports, freight vehicle productivity is defined as freight per vehicle, and comprises two components:

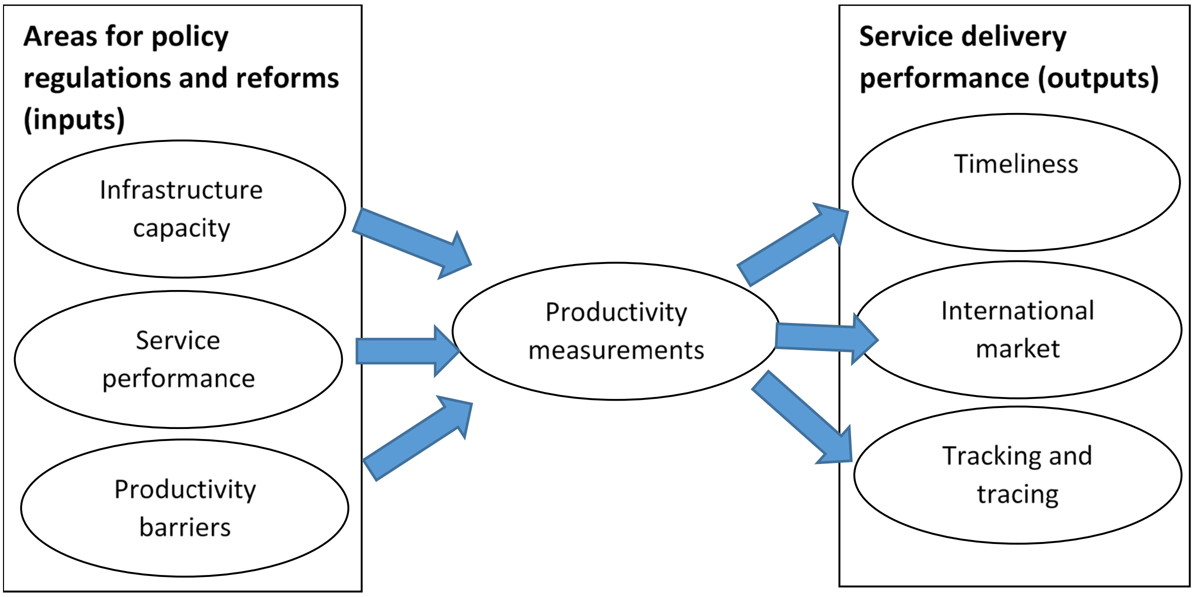
- average vehicle load—freight per vehicle kilometre
- average vehicle utilisation—annual vehicle kilometres per vehicle

Improvements to existing datasets and new data related to productivity indicators, for example, could improve the evidence-base upon which Ministerial advice is developed across a range of freight-related issues such as freight charges, energy consumption, congestion, infrastructure assessment, industry regulation and the economic impacts of government policy, as shown in Figure 3-5.

With strong growth projection in the freight task, state and local governments are looking for ways that could potentially enhance productivity associated with the growing freight task. Increasing usage of high productivity freight vehicles (HPFVs), which are larger in size and have higher load capacities, and upgrading the road network to provide the required maneuver by HPFVs are examples of the importance of productivity.

[9] See, for example, *The Role of ICT in Australia's Economic Performance*, Banks (2001).

Figure 3-5. Productivity measurement inputs and outputs



3.4.1 Existing information on productivity and performance measures

Productivity measures can be indirectly derived from the SMVU published by ABS (2017) where the laden and unladen NTK of road freight vehicles are reported.

There are a few information about the infrastructure capacity and service performance of rail freight task in the TrainLine reports, published by BITRE (BITRE, 2017b). Rolling stock of locomotives and their age also have been reported by BITRE (BITRE, 2012b) where the analysis has been presented for locomotives that perform almost freight duties only, and requirements of Rolling stock has been presented in (ARC infrastruture, 2018) and ARC[10]. Rail freight performance indicators are presented in a series of reports published by BITRE (ARA, 2005; BITRE, 2007-08; ARTC, 2018a; ARTC, 2018b) including information on regional maritime railway services to city ports (the information on gauge and type of products transported by rail network).

Train indicators have been reported by ARTC (ARTC, 2018b) including: (i) scheduled intermodal transit time (transit time for all trains on the line segment, irrespective of ultimate origin or destination); (ii) actual intermodal transit time (average transit time of intermodal trains operating point-to-point between two cities); (iii) number of stops; (iv) train service frequency; (v) average speed, and train reliability on the interstate network. These indicators were derived from the data provided by ARTC, FreightLink, Queensland Rail Network Access, RailCorp and WestNet.

The ARTC also publishes performance indicators relating to key service quality areas including reliability (ARTC, 2018a). In another report, ARTC reports track indicators11 including train length,

[10] http://www.arcinfra.com/ARCInfrastructure/media/documents/Network%20Specifications/ARC_Sheet_Rolling-Stock.pdf
[11] https://www.artc.com.au/uploads/PIR_Track-Condition.pdf

double stacking capability, dwell time and number of stops, and track the quality of the interstate network.

There are also two main government-funded sources publishing productivity measures in sea transport, BITRE (2018e) and ACCC (2018). The Container Stevedoring Monitoring report provided by ACCC (ACCC, 2018) aggregates throughput information provided by container stevedores DP World, Flinders Adelaide, Hutchison, VICT, and Patrick. Notably, a comparison of the two organisations measure of throughput is required to clarify the differences and similarities between these two resources. There is data about labour productivity in the stevedoring sector which include elapsed labour rate (i.e. the number of containers handled for the period between labour first boarding a container ship to labour last leaving the ship, except any time when labour was not working due to delays) (ACCC, 2018).

The methods of ACCC and BITRE for some of the performance indicators are different. For example, ACCC (2018) compares the crane handling rates and container handling charges were compared on a trade basis for the same ships calling at the ports on each trade. Different size ships tend to be used on different (shipping) trades. All other things being equal, newer and larger ships lend themselves to faster crane working rates. This ship tracking approach to obtaining comparable international data differs to that taken by the BTRE in its Waterline publication. The BTRE, which focuses solely on domestic performance, publishes data on a port basis by aggregating information for container ships of all sizes visiting each of Australia’s major container ports.

Moreover, the container handling rates used by ACCC (2018) are not measures of economic efficiency. They are a partial measure of technical efficiency, reflecting the application of labour and capital resources. They do not indicate whether handling rates are being achieved using the most economically efficient mix of these resources, given their relative costs.

Among private data points, 1-stop records online and historical performance and productivity metrics of truck, rail and container terminal operators. However, this data is not available. Lastly, the Port Botany Performance Data Mobile App is one of the rare platforms providing data about the performance and productivity metrics of freight operators in the Port of Botany.

In air productivity, the utilisation of the regional airport has been reported by BITRE (2013) where percentage of passengers is used as a proxy to indicate utilisation(BITRE, 2013)(BITRE, 2013)(BITRE, 2013). Additionally, operators such as Qantas present some information useful to indirectly derive the productivity measures such as unit load, configuration, network coverage, equipment and capacity available for freight (Qantas, 2018c), plus a dedicated national and international freight routes in a map (Qantas, 2018a; Qantas, 2018b). However, further than this information, there are no particular productivity measures for the air freight task.

3.4.2 Limitations and gaps

The lack of more granular productivity measurements has been raised in the National Land Transport Productivity Framework study by the NTC in 2017 as follows:

> “*Existing transport productivity measurements, while useful, do not adequately support evidence-based transport policy decisions. Currently, there is no productivity framework with performance*

measures to help ensure Australia is investing wisely in productivity-enhancing reforms (or infrastructure)."

The limitations of productivity issues are as follows:

1. As raised by the NTC (2016), the national industry-level productivity estimates do not include ancillary road freight operators, and private transport use in the industry, and is mainly focused on the organisations providing transportation activities. Additionally, only 32 per cent of all road transport operational costs are captured in the transport, postal and warehousing sector. One of the main reasons for this limitation in productivity estimates is the lack of data on private sectors and ancillary operators.

2. While there are several productivity measures reported in various data points, these are limited to partial measures where only one or two factors have been considered. A limitation of partial productivity measures is that they attribute all of the productivity improvement to one factor when, in fact, productivity growth may be attributable to several factors. Total, or multi-factor, productivity measures avoid the limitations of partial measures by measuring the growth in total output per combined unit of all factor inputs. For example, the container handling rates in (ACCC, 2018) are not measures of economic efficiency. They are a partial measure of technical efficiency, reflecting the application of labour and capital resources. They do not indicate whether handling rates are being achieved using the most economically efficient mix of these resources, given their relative costs.

3. There are no productivity measures for air freight and coastal shipping, and there is a lack of information in the existing reports about the fleet utilisation for the rail and road modes.

4. Furthermore, the Trainline reports do not show the degree of any type of locomotive usage. With the status of the locomotive fleet is highly fluid, with locomotives frequently becoming operational or going into storage, BITRE is currently unable to measure locomotive usage. Care is also needed when comparing locomotive ages by gauge, particularly between the broad and standard gauges, where there is considerable re-gauging of the previous Victorian government owned locomotives.

5. Between two main sources publishing the productivity measures in sea transport, BITRE (2018e) and ACCC (2018), a comparison of the two organisations measure of throughput is required to clarify the differences and similarities between these two resources.

6. Due to the privatisation of the five major Australian ports, the 'new' seaport operators are not motivated to provide the necessary information to either port authorities or to the state and the federal governments. For example, while '1-stop' records online and historical performance metrics of the truck, rail and container terminal operators, these data are not publicly available, nor do port authorities have access to it. The 'Port Botany Performance Data Mobile App' is one of the rare platforms providing data about the performance of freight operators in seaports.

7. Considering productivity measures derive from private businesses, the data are hard to come by and interpret, and even access to good data does not guarantee a harmonised and uniform

comparison. However, as suggested by Hamilton (1999), the results of performance measurement can affect the interests of stevedores, unions, port authorities, shippers and governments, so there is an incentive for some to take advantage of the difficulties of measurement to promote their interests. This has certainly been true in the Australian experience about seaport operators.

8. Lastly, as suggested by Hamilton (1999), there are so many variables, even within a single terminal, that might produce differing conclusions about productivity. Accordingly, comparing the performance and productivity measures at the international level is tricky. For example, comparing various Australian stevedoring crane rates is reasonably acceptable because many of the unmeasured influences, such as the type of ship and terminal capital equipment, are the same at each Australian port. However, comparing Australian stevedoring crane rates with other national crane rates is fraught with danger when the unmeasured influences are not considered.

3.5 Data on labour, fleet and operators

Improved labour skills and their satisfaction have been a central component of increasing the freight productivity. While the Australian freight and logistics labour market are aging, there are other issues that should be taken care of such as lack of gender diversity, lack of skill for certain commodities, and satisfaction issues. Planning requires information about labour classified by age, skill, gender per transport mode and fleet. Critical information about fleets and operators include the number and types of vehicles specifically engaged in the 'business of freight transport', utilised fleets in road and rail freight transport, fleets classified based on the for-hire companies, third-party contractors or business where transport is ancillary to the core business.

3.5.1 Existing data on labour, fleets, and operators

The employment data in transport, logistics and warehousing sector has been provided by ABS (ABS, 2016), although has not separated for passenger and freight and mode of transport. The employment data has not been categorized for passenger and freight in other data points such as rail (AISC, 2018), air (AISC, 2015), and shipping sector (Ports Australia, 2015). However, it seems the information about aviation workforce is more detailed in a report by AISC (2015) where it includes information about the age, gender, and ethnicity profile, hours worked, educational attainment, and staff expenditures.

There are only a few dissemination reports about the issues around labour in freight and logistics industry. NSW Customer Services Division (2017) is one of the rare sources providing an online tool to present the satisfaction level of heavy vehicle drivers using the NSW road network. Satisfaction was measured on several factors namely journey time reliability, safety, and road quality, design, signage and markings, information, customer service, licensing and registration, tolling, and facilities.

Lack of skill also was studied in a survey by ALC (2002), where it turned out that an average 63% (range 38%-100%) of operational workers lacked the skills and knowledge to load perishable food products, in particular correctly they lacked a knowledge of food safety, the airflow requirements of products and space efficient methods of bracing loads to ensure airflow. Additionally, a study by the

Australasian Railway Association (ARA, September 2017) identifies several other challenges linked to workforce skilling aimed at growing the capabilities of individuals and companies within the rail sector.

Another issue is the lack of gender diversity in the freight employment market. According to WISC (2014), the transport and logistics sector is male dominant and described as a non-traditional sector for women. According to a Transport and Logistics Industry Skills Council (TLISC), over the past five years the industry has had a 58% growth in employment, however, only employs 14% of women. The transport and logistics industry gender pay gap was 16.1% between November 2013 and May 2014. (WISC, 2014). Although this report provided data about the percentage of females in the transport, postal and warehousing sector workforce, the figures have not been separated for the freight and passenger transport (WISC, 2014).

Registration systems are also a primary source of information about the national operator and fleet profile. State and territory road agencies are the source of NEVDIS (i.e. National Exchange of Vehicle and Driver Information System) data. This data includes the national Vehicle Identification Number (VIN) database and the national Written off Vehicle Register (WOVR) database. However, this data is not publicly available.

3.5.2 Limitations and data gaps

The following limitations and data gaps have been identified:

1. As raised by NTC, there is lack of information about the labour per fleet and workforce salary.
2. A major data gap identified by NTC (2017), is the composition of the freight vehicle fleet in detail, including trailer and axle configuration for road vehicles and the split of ancillary versus hire-and-reward operators (not just vehicles) involved in road freight are among important existing data gaps.
3. In some reports such as BITRE (2009), the Australian employment in the transport and storage industry is provided, however, this data has not been separate the passenger and commodities movement.
4. Due to the lack of data about labour in the freight transport sector, we are also unable to predict future trends in terms of labour supply, licensing, skill and training needs.

3.6 Data on network, infrastructure, and land use

An effective freight transport network is essential for long-term economic development. A strong freight network ensures remote, regional and metropolitan businesses and communities have reliable access to goods and services. It underpins the capability to move these goods efficiently and sustainably thereby making a substantial contribution to overall productivity and prosperity.

One research suggests that in general Australian supply chains do not suffer from the “tyranny of distance”.[12] For the most significant export chains, in particular, iron ore and liquefied natural gas

[12]https://infrastructure.gov.au/transport/freight/freight-supply-chain-priorities/research-papers/files/International_comparison.pdf

(LNG), Australia enjoys geographical advantages over its main competitors. For the containerised, vehicle and product oil (refined petroleum products) import chains, Australia benefits from the demographic advantage that most of the population is concentrated in the coastal capital cities. These are within easy reach of ocean shipping, which is by far the most efficient and environmentally friendly mode of freight transport.

It seems that that the primary obstacle to more efficient logistics is congestion in urban areas, first and last mile accessibilities, and network resilience due to natural disasters. The term 'first mile' or 'last mile' generally describes the short distance required to connect a business, farm or similar facility (a freight origin point) to an existing heavy vehicle route; and/or to connect the heavy vehicle route to a port, freight yard, silo or drop-off point (a key freight destination point). Productivity issues arise when there is a mismatch between the freight vehicles allowed on a heavy vehicle corridor and the short section connecting an origin/destination point into that corridor – the first or last mile (SAFC, 2015).

According to SAFC (2015), addressing first and last mile issues has the potential to increase road transport productivity by up to 50% for some businesses. For example, in an article by Baker et al. (2017), unsealed roads can cause damage to livestock as a result of dust inhalation and jarring and, for example, avoidance of this damage is estimated in the manual to be worth $0.909/km for each B-double or Road train which travels along a route that is upgraded from a roughness index value of MRS1 or 2 to MRS 5+.

It is important to identify what inland routes are resilient in times of flood and how they connect markets. For example, with recent increases in on-farm storage of grain, there is a parallel increase in the number of farmers who are supplying grain for export on a "just-in-time" delivery basis and receiving a price premium for doing so. Such delivery is dependent upon freight transport being able to access farms. Access is potentially threatened when roads are unsealed and liable to closure during rain events.

According to Baker et al. (2017), the practice of economic appraisal of road upgrade projects is well developed at state and federal level within Australia. All States employ a cost-benefit appraisal framework as the primary tool for economic evaluation, and each publishes guidelines which set-out how such evaluations should be undertaken (see, for example, DTF Victoria, 2013; Treasury, 2015; NSW Treasury, 2017).

In NSW and Queensland, these general guidelines for the conduct of CBA inform the more detailed manner in which CBA is specifically applied to transport infrastructure projects. These more specific procedures are detailed within (TMR, 2011b; Transport for NSW, 2016). Both of these documents are generally similar in terms of the types of costs and benefits they consider, although there are differences in the parameter values they each employ and the Queensland manual provides more detail on the treatment of benefits with regard to sealing of rural roads than do the NSW guidelines. Costs are specified in terms of the capital costs of undertaking a project and the maintenance cost associated with the new infrastructure. Benefits are generally categorised as: Value of travel time savings (VTTS); Vehicle operating cost (VOC) savings; Accident savings; Environmental benefits; Other benefits such as the value of travel time reliability (VTTR) and wider economic benefits (WEBs).[13]

As some data for the cost-benefit analysis the frequently provided by NSW, it seems that similar data are required for other states. However, as the methodology of analyses is provided in the Baker et al. (2017), an online dashboard can be provided to public users or some specific organizations that conduct the analysis of the impact of the transport improvements of the economy and provide reports frequently.

3.6.1 Existing information about network and infrastructure

The national key freight routes map that is provided by DIRDC (2015) presents the key freight routes including key freight road route, secondary freight road route, key freight rail route, intermodal terminals, road train assembly area, major seaports and major airports are provided in different layers of the map. The interstate transport network is presented in (BITRE, 2010a) and a journey planner by National Heavy Vehicle Regulators (NHVR) also provide the information about distance and travel times for inland routes (QTLC, 2015).

A geographical representation of all railways, airports and other transport terminals has been provided by Australian Government[14], among which all the freight train lines along with other facilities for transport. It is a government run visualization tool. Additionally, lines owned and operated by ARTC and ARC (interstate) are presented in ARTC website[15]. In 2010, the ARA commissioned a network classification map to provide a high-level overview of the axle loads of various rail track networks across Australia. Two versions are available, a national map and state-by-State map. This is a compilation of axle load information available across various sources[16].

Several other data sources about network and infrastructure provided by state governments, mainly by Victoria, NSW, and Queensland.

VicRoads provides datasets via API about Melbourne Container Network, and Port of Melbourne's gazetted roads for Container Vehicles (VicRoads, 2018d), road classification and B-double network (VicRoads, 2018e), higher mass limit routes (VicRoads, 2018a), A-doubles network (VicRoads, 2018f), HPFV mass restricted bridges (VicRoads, 2018b), and HPFV mass road restrictions (VicRoads, 2018c) under a Creative Commons Attribution 4.0 International Public License.

In NSW, Transport data for minor roads and hubs has been provided by NSW government including network connectivity and characteristics such as type, name and potential restrictions on what can be moved through the network is presented in an online tool (DFSI, 2018g; DFSI, 2018a). Some other spatial datasets are provided by NSW government including position of road segment, road name extent, aggregated way, aggregated way segment and crossing (DFSI, 2018d), Impediment (DFSI,

[13] WEBs relate to the additional economic impacts of transport infrastructure investment in terms of agglomeration economies, and increases in competition, labour supply, and productivity.
[14] https://nationalmap.gov.au/
[15] http://www.arcinfra.com/ARCInfrastructure/media/documents/Network%20Specifications/ARC_Map_Network.pdf
16 https://ara.net.au/sites/default/files/u1/TrackClassificationsMapState_2010.pdf

2018c), heavy vehicle check stations (DFSI, 2018b; RMS, 2018a), tollbooth location (DFSI, 2018e), and gates locations (DFSI, 2018f).

In Queensland, TMR (2018b) provided an online tool to find the heavy vehicle routes. This tool identifies the approved routes for Heavy Vehicle Multi-combination and Higher Mass Limits use. Accordingly, traffic and road condition information captured in the QLDTraffic system is available for use by external developers via GeoJSON feeds. These feeds cover hazards, crashes, congestion, and flooding, roadworks and special events and web cameras details (TMR, 2017b). Moreover, other information is provided via an online tool namely: heavy vehicle routes and restrictions (TMR, 2018b; TMR, 2018c), state-controlled roads bridges (TMR, 2018e), the location of toll booths (DFSI, 2018e) and gates (DFSI, 2018f), and location that the traffic data is collected (TMR, 2018d). Finally, there is a RSS feed provided by QLD Government (TMR) that provided feeds for incidents, special events, roadworks and closures/limits (TMR, 2017a).

Notably, Queensland has a long history of major natural disasters, typically involving cyclones and flooding that predominately impact coastal Queensland. This establishes the requirement for a resilient infrastructure network to support a number of Queensland's major economic supply chains (eg. FMCG, livestock, and grain, fuel, and horticulture), especially in times of natural disaster (QTCL, 2015). According to THLGC (2014), restrictions of the network in Queensland has caused the shortage of competitiveness between the two modes of rail and road.

SAFC (2015) provides the maps illustrating the Access to/from Ports and intermodal terminals in South Australia, B-double accessibility and trucking depots.

Lastly, commodity-based network accessibility issues have been reported in a few state-based studies. For example, industry call for less restricted operation of "over-size over-mass" vehicle permits for the sugar cane industry (ASA, 2013); rail accessibility for the cotton gins (BITRE, 2018e), upgrades of current low quality roads for mining and energy in Western Australia[17] (ACIL, 2009), and accessibility issues of energy-related commodity items (eg. coal, iron ore, and LNG) (BREE, 2012).

3.6.2 Limitations and data gaps

The following limitations and data gaps have been identified:

1. There is a lack of data on rural roads. According to (BITRE, 2015a; BITRE, 2018e; BITRE, 2018c), information on the size and scope of rural and agricultural commodity transport tasks is particularly lacking. This limits the information base for infrastructure planning, both in terms of understanding current transport flows and in assessing infrastructure bottlenecks, and inhibits governments' ability to develop appropriate policy responses and assess competing infrastructure needs. The lack of adequate information and timely investment can ultimately affect costs faced by agricultural producers who face increasing input costs, as well as seasonal and climatic challenges.

[17] For example, the Tanami road in the East Kimberley, access roads to the north Kimberley off the Gibb River road, and a road to service the LNG / gas processing hub at James Price Point.

2. There are insufficient studies on the impact of improving, or construction of new transport infrastructure on the freight task. According to Baker et al. (2017), pilot studies with wider selection of roads and economic and social contexts has been recommended. It is believed that in addition to its research value, these pilots would offer a highly visible and participatory way of engaging rural stakeholders in policy debates regarding infrastructure as well.

3. There is little or no data which indicates the network resilience in the case of natural disasters. The data should be collected on the road closures, the duration, and alternative plans should be foreseen. This problem extends to rail transport as well. Lack of data on the complementary facilities within the rail industry also limits planning for the resilience of the network.

4. While governments of all levels need to ensure the 'last mile' issues that inhibit productivity growth are identified and addressed, there is a lack of data about the issues of first and last mile delivery including accessibility issues for heavy vehicle and rail. Thus, the data need to be collected about the loss in products because of any issues related to the first and last mile including the delay, and costs imposed by a mismatch of operators working hours or expertise, network access, capacity issues and regulatory constraints.

5. There is a lack of integrated land use plans and freight transport models. In all strategic freight transport models, the status quo land use information is used as explanatory variables to estimate the production and attraction of freight movements. However, land use is categorised into limited and vey aggregated classes such as commercial, industrial, transport and warehouse. There is lack of detailed information on the type of land use in order to make more realistic assumption from modelling perspective.

3.7 Data on cost and economic contribution of the freight system

Transport statistics are influenced by a range of economic factors, including changes in the production of physical goods, the demand for passenger travel and changes in international trade in goods.

Freight rates are a key factor influencing freight mode choice, and directly impact the costs of freight-reliant business sectors, such as mining, construction, retail and wholesale trade. As a business input cost, they affect the profitability of Australian industry. Costs enter the truck productivity model as average variable vehicle operating costs per tonne-kilometre which include fuel, labour and vehicle registration charges. Notably, some other costs such as vehicle maintenance and (amortised) vehicle capital costs are missed in such models (BITRE, 2011).

All cost, revenue, and economic contributions of freight transport task will be an input for the Transport Satellite Account (TrSA), which is now waiting for funding. The TrSA provides a systematic and consistent framework and dataset for analysing the role of transport in the economy, both on an industry and product basis. The proposed framework for Australian TrSA measures transport activity for both own-account and for-hire transport services, including expenditure, income, volume data, employment, industry level GDP and estimating profit on own-account transport activity. A TrSA would use the framework, concepts and definitions from the System of National Accounts, supplemented with additional transport related data, to produce a credible and comprehensive measure of the contribution of transport activity to the economy at the national level.

3.7.1 Existing data of costs and economic contribution of freight transport

ABS (2012) provided data about the incomes of the road freight transport for 2010 and 2011 Australia wide. The information on revenue is available within the annual financial report of the specific airports but not separated for freight and passenger, and no information has been found on the revenue of the rail freight sector. ACCC (2018) provides continuing reports on revenue per lift, total and per unit (quayside, landside and other revenues). Total revenue reported in this study accounts for all revenue that stevedores earn across their suite of services, from 'quayside' services to shipping lines as well as from 'landside and other' services.

Road freight operational cost can be found on the (Freight Metrics, 2018), or an estimation provided by Aurecon (2013) for two types of truck, and the freight rates for mainland inter-capital routes by SKM (2013). The real air freight and rail freight rate index has been provided by Department of Infrastructure (2008), and total and per unit operating costs incurred by container stevedores are reported by ACCC (2018) on a regular basis.

Some information on rail freight rates in Australia is available from BITRE 2008 (Information sheet 28). More detail about the cost of freighting containers by rail for two corridors (Melbourne- Brisbane and Perth-Cairns) has been provided by BITRE (2018e)). ARTC (2015) additionally provides comparisons of the existing coastal rail line between Melbourne and Brisbane, and the proposed inland rail project per segment.

However, various sources use different definitions to measure the cost. RIRDC (2007); SAFC (2010) breakdown the different types of costs associated with freight and transport including private (monetary) costs, market cost, and external cost. Moreover, this study provided the sources to find the governmental and non-governmental variable and fixed monetary road freight costs. TMR (2011a) classifies the cost into vehicle operating costs, travel time costs and accidents costs and externality costs for transport infrastructure projects.

It should be considered that from the commodities movement view, the cost of freight (or an average cost of freight) is a unique number that varies based on the freight mode and the services that freight transport provide. For example, according to Aurecon (2013), the 'fresh commodities' supply chain is more expensive than corresponding containerised services.

ABARES (2018a) is an online platform is provided with the cost parameters for agricultural commodities (eg. wheat and other crops, livestock, and beef) for various farm sizes and states. These costs include but not limited to wage for hired labour, handling and services. According to ABARES (2015), BITRE's road construction and maintenance price index and the National Transport Commission's road wear model are high levels and further methods will be needed to understand and anticipate costs for road investment in specific areas, such as wheat producing regions.

3.7.2 Limitations and data gaps

Our study has highlighted a number of data limitations and gaps, as follows:

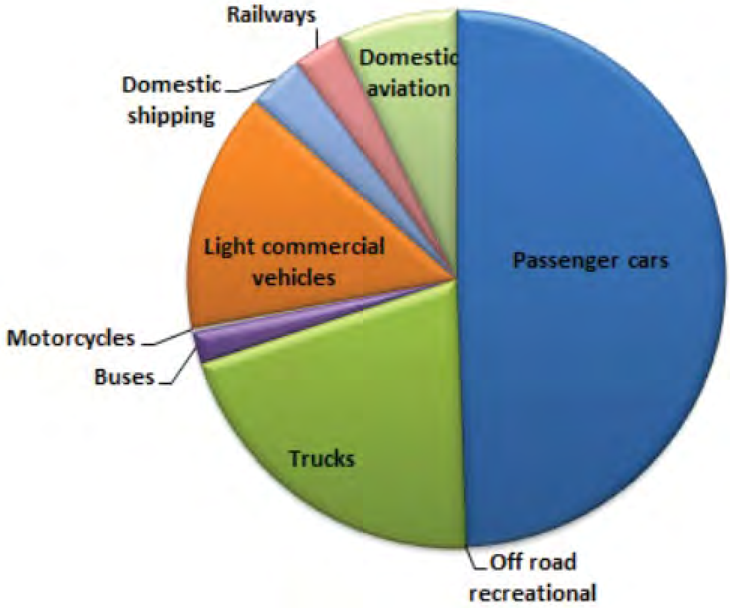
1. Transport costs for commodity-based movements are typically commercially sensitive and not publicly available. For most reports, BITRE has made assumptions about modal transport costs based on available public information and its own best judgement about relative costs.

2. There is no data about the indirect costs of road transport such as the costs of externalities as well as infrastructure (eg. pavement).
3. The 'Port Interface Cost Index' needs to be updated. A paper by Infrastructure Australia and the National Transport Commission (2010) also reviews the appropriateness of the Port Interface Cost Index as a strategic policy and planning tool. The Port Interface Cost Index is "intended to measure the average cost of moving a container (measured in TEUs) through a port and is "designed to capture the *most* significant costs involved in these movements". The main cost elements of the Index have remained unchanged since it was first published in 1993 are: (i) Port and related charges; (ii) Stevedoring charges; (iii) Customs brokerage; and (iv) Road transport charges. The current Port Interface Cost Index provides only the metropolitan component of the task. Part of the complexity is that there are many parties involved in the import and export of container supply chains.
4. There is a lack of data about the cost of air freight. Related cost for airports are calculated on a passenger level. With the airport charge calculated in per return passenger basis, there is no information on freight charges. Airport charges are estimates of what an airline may expect to pay based on available information published or provided by airports and Air services Australia. Airport charges are intended to show the differences between airports and also the change over time.
5. There is a lack of mode-specific commodity-based cost metrics.

3.8 Data on the sustainability of freight

Freight transport can have adverse noise and air pollution impacts, particularly on communities living in close proximity to major freight routes, and they account for a significant share of emissions in the whole transport sector, as shown in Figure 3-6. As such, it is important exploring ways and means to better manage heavy freight across the freight network and its impacts.

Figure 3-6. Share of Transport Emissions in 2009 (Department of Climate Change and Energy Efficiency, 2011)



3.8.1 Existing information about sustainability and environmental impacts of freight

BITRE (2018f) and PTT (2016) publishes the road transport direct greenhouse gas (carbon dioxide equivalent) emissions grouped by vehicle type, from 1989-90 to 2016-17. These emissions are simply calculated based on the fuel consumption and kilometres travelled of various vehicle classes that are published in the BITRE reports. However, this information is limited to the road sector and suffers from simplification of estimation. BITRE (2017b) and ACG (2007) provide estimates of rail activities emissions.

The consumption of fuels by freight industry is published in a few reports. For example, the number of registered vehicles using petrol as fuel is provided by the ABS (2018, 2011c, 2017).

Other state-based data exist such as the data about the road transport noise on state-controlled roads in Queensland (TMR, 2018h), the impacts of use of electrically powered vehicles on reducing emissions (RMS, 2017), comparison of the level of the noise for rail and road in Western Australia (Freight and Logistics Council of Western Australia, 2015).

3.8.2 Limitations and data gaps

The data gap related to sustainability of freight system is a big impediment of improvement planning. These data if exist helps the operators to reduce their negative impact on the environment. The data gaps can be outlined as follows:

1. There is a lack of information on environmental impacts of freight task by transport modes (air and noise pollution, soil quality, land take, and biodiversity).

2. There are not enough sustainability studies and action plans with regards to the freight transport system.

3.9 Data on freight transport safety

Safety is a top priority for the freight logistics industry. Maintaining and improving safety not only makes good business sense, it also fulfils the industry's commitment to achieving a safe supply chain for all users, including members of the industry and the travelling public. A fundamental safety principle in the transport industry is that all participants in the supply chain who control or influence the movement of freight have a responsibility for safety. This shared approach to safety underpins the Chain of Responsibility concept in the heavy vehicle industry. (TMR, 2018f).

Accordingly, the Australian Logistics Council (ALC) has developed the National Logistics Safety Code (NLSC). The NLSC provides the industry with a simple and effective way to improve and maintain safety across the supply chain and to meet their Chain of Responsibility requirements. The ALC Codes, which also include a Steel Code and Coal Seam Gas Logistics Safety Code, adopt a risk management approach and set out all participants' responsibilities when they control or influence the movement of freight. It also tests compliance through a rigorous audit regime, so that businesses can continually update and improve their safety systems (TMR, 2018).

3.9.1 Existing data on freight transport safety

Increasing interaction between large trucks and other vehicles is of interest to planners. In theory, information about location-based accidents enables planners to manage better the impacts of for example fatigue management plans (relocating the designated resting areas), infrastructure reform projects, or the imposition of stricter heavy vehicle regulations.

The Australian Road Deaths database published by BITRE (2018b) provides basic details of road transport crash fatalities in Australia as reported by the police each month to the State and Territory road safety authorities. Details provided in the database fall into two groups: (i) the circumstances of the crash, for example, location, crash type, day of week, time; (ii) details regarding the persons killed, for example, age, gender and road user group.

Crash data from Queensland roads (TMR, 2018a) is one of the comprehensive open datasets in this area which include information on location and characteristics of crashes in Queensland for all reported road traffic crashes occurred from 1 January 2001 to 31 December 2017, fatal road traffic crashes to 31 December 2017, hospitalisation, medical treatment and minor injury crashes to 31 December 2017 and property damage only crashes to 31 December 2010. Other examples for the other states are crash data in SA (2017) reporting crashes for the last five years (2013-2017), and ACT crash dataset (Government, 2018) reporting spatial locations crash data since 2012 up to now.

The Australian Transport Safety Bureau (2012) also reports the rail safety figures such as railway accident fatalities, injuries, and cost of collision and accidents.

4 Key findings

4.1 Improving the efficiency of the overall freight task

In Australia as elsewhere, freight is delivered through an integrated system that is comprised of multiple independent, but interdependent components. The Australian freight system has evolved over time, arguably somewhat haphazardly and limited by our Federal structure, to meet new needs, rather than according to some longer-term coordinated strategy. For example, rail, road, sea and air networks have evolved somewhat independently, particularly before increased federal government involvement in national roads investment prioritisation.

With better data, there is an opportunity to plan for a system that can better coordinate the future need for a significantly expanded freight task, and to make freight movement in Australia more efficient and more effective at meeting the needs of final users. Freight costs, speed of movement, and product quality, have substantial effects on other parts of the economy. Improving the freight system efficiency will have positive impacts on GDP and economic growth.

Supply chain visibility offers a window in to this freight system, providing insights in the linkages between different transport modes, as well as how modes operate in parallel so as to enable relative benchmarks on efficiency to be determined. Supply chain visibility can also support more nuanced, granular adjustments to the freight task. These benchmarks can also be compared with the international benchmarks described in this report (and many others) to enable policymakers to map out a long-term strategy at a national level. This strategy should take account of the increasing freight task to meeting an expanding economy driven by a rapidly growing population.

A strategy to collate and make available better data must account for technological progress (most particularly automation) that is sweeping through the different transport modes at different rates, with ports leading the way, followed by rail and then road. Intermodal connections face the greatest complexity in implementing automation, yet these linkages are potentially the most important as intermodal transfer is a key source of productivity loss in the system due to limited interoperability between the nodes. Data on interoperability will hence enhance the ability of policy makers to coordinate across the system, and relieve the points of greatest friction in the system.

There are important other areas where improved data would enable better planning, both on the part of governments and private sector operators. While automation has arrived for some freight modes and geographies, it is far from being common. In the meantime, an outcome that is already observed are labour supply shortfalls in road transport, and, more broadly, an aging population of drivers and operators in freight industries. These labour shortages affect the capacity of the freight system to deliver and have to be factored in to the data architecture to gauge the impact on productivity and total freight task.

Every system also has redundancy. Some of this redundancy exists to deal with bottlenecks during peaks, for instance, during harvest times. However, a lot of redundancy can simply emerge from established practices, a lack of communication or limited coordination. An effective system-wide analysis must be able to identify designed redundancies that benefit the system, and those non-designed that create friction and reduce the efficiency of flows within the system, which ultimately impact the effectiveness of the entire system to do what it is meant to do – deliver freight at the greatest speed at the lowest cost while maintaining the highest quality of the freight being delivered. All of this requires a far more expansive data architecture than currently exists, or which currently exists in an atomistic unstructured and unintegrated way.

Building a robust data architecture also supports the convergence of technologies, including the thousands of apps that can enable increased connectivity of the data capture, curation, analysis and output delivery processes for better network coordination. However, quality of data also depends on the curation of the data, which includes consistent definitions across the entire system. A system where data is not articulated, as is currently the case in Australia, will also display a proliferation of definitions of freight movement, volume, timing, and other performance measures that complicate any meaningful analysis.

Short-term gains from productivity improvements at the fleet and operator levels need to be supplemented by effective coordination across the entire system. Improvements through integrated coordination schemes will provide some benefits. However, in the long-term decisions on network infrastructure will ensure that the freight system has the capacity to deliver more efficiently. Here, better data can support supply chain efficiency through informed decisions about investments in infrastructure and freight corridors. Relatedly, broader freight efficiency objectives that incorporate the whole system establish the need for a two-way communication and decision-making flow between governments and planners, on the one hand, and operators on the other.

As such the solutions going forward need to be driven by a system wide design agenda. This requires the involvement of all those who will benefit from improvements. Involvement means making data that is traditionally seen as private and commercially sensitive to be made available by fleet operators to reduce the gaps in knowledge about the operation of the freight system as a whole. This currently private data, if shared, will enable more effective long-term decision making on infrastructure requirements which will benefit fleet operators sharing the data.

4.2 Australian freight data - key themes

This review has identified over 350 private and public datasets or ad hoc reports related to Australia's freight supply-chain. Although the amount of information across many aspects of freight transport is extensive, there is still much room for improvement. Our review of the available freight industry datasets and data gaps has revealed a number of themes.

4.2.1 The data needs of the public and private sectors are different

This study identified the different perspectives and requirements of private firms and government agencies. Going forward, this delineation must be kept in mind when designing new data collection methods or approaches to standardising existing datasets. Adopting an inclusive outlook is a key requirement of bridging the data gap, mainly because of the divergent perspectives and timeframes of the private sector and government. Data should be collected, analysed, and presented in ways that are meaningful and useful to all key stakeholders. The more inclusive data can be used to improve individual firm productivity in the short term and inform when and where public and private investments are needed in the medium and long-term.

4.2.2 Measures and indicators should be harmonised to enable siloed data to be aggregated

One of the most obvious areas for improvement is to create internally consistent freight data for those areas that are often siloed (at the firm- or state-level). Doing so will generally require that measures and indicators are harmonised or meet agreed standardised definitions. Common data standards are also are necessary to improve visibility of the supply chain and coordination schemes, as confirmed in a pilot study by Austroads (2017).

4.2.3 There are issues about the national data points

Undertaking the national data surveys is costly and requires time-consuming data cleansing and analysis. As a result, data are only released to the public after a long time lag. The cost of surveys is an important impediment to achieving a suitable sample size, enabling surveys to be done on a regular basis and at a suitable level of granularity. Hence, there is critical information missing in the freight task data such as seasonal variation, activity-based and commodity-based information.

4.2.4 Where possible, government policies should support a more pro-active data sharing approach

The fact that four of five major ports in Australia do not publish data about the freight tasks and operations at their precinct highlights the importance of putting in place data procedures before privatising. More broadly, government support of infrastructure investments or joint ventures with the private sector could be made contingent on data subsequently being made available for the benefit of the broader community.

4.2.5 Strategic freight planning requires asking 'how and why' and 'what, where, when and how much'

While freight data are available in aggregate at the national level, planning for the future requires far more detailed information. For instance, comparisons of alternative transport modes; measuring capacity across freight corridors, modes and terminals; assessing the growth or decline of freight tasks over time; seasonal and cyclic variations in specific freight tasks; and metrics of freight costs all require a far more granular and sophisticated data capability.

4.2.6 There are solutions for enabling visibility while maintaining confidentiality of data

Privately-owned data are not often shared with the government, let alone competitors, due to data confidentiality issues, and lack of data sharing procedures. In many cases, data could be treated as a public asset, anonymised, encrypted and published in an open and usable format so that third parties (such as researchers, analysts, and app developers) can re-use and create value from that data.

Integrated customs data which became available for modelling and planning purposes by removing identifiers is one example of how this could be done.

4.2.7 Information asymmetry and lack of interoperability in Australian supply chain creates inefficiency

Initiatives such as Trade Community System, Cargo Management Co-ordination Centre can overcome the problems of lack of information exchange and interoperability. These pilots can be expanded and integrated into users' systems so as to properly validate and test the commercial and technical issues of coordination and integration schemes.

4.3 Classifying industry needs, by stakeholder

Figure 4-1 represents the data needs that stakeholders likely require to improve the efficiency of their operations, their competitiveness in the market, or, in the case of government, to make better planning and investment decisions. Accordingly, the first step to address the data gaps is to understand the nature and key causes of individual data gaps and potential barriers ahead, so that a more suitable recommendation can be proposed. The second step is exploring the benefits of each individual item of data, if collected, for different stakeholders in short-term and long-term. Table 4-1 presents the eight main freight data gaps and two top specific gaps in each item. Table 4-2 then refers to each of the identified gaps by indicating how they are caused, how different stakeholders might benefit from gaps being addressed, and a proposed solution for closing the gaps.

Figure 4-1. Stakeholder needs of data/schemes

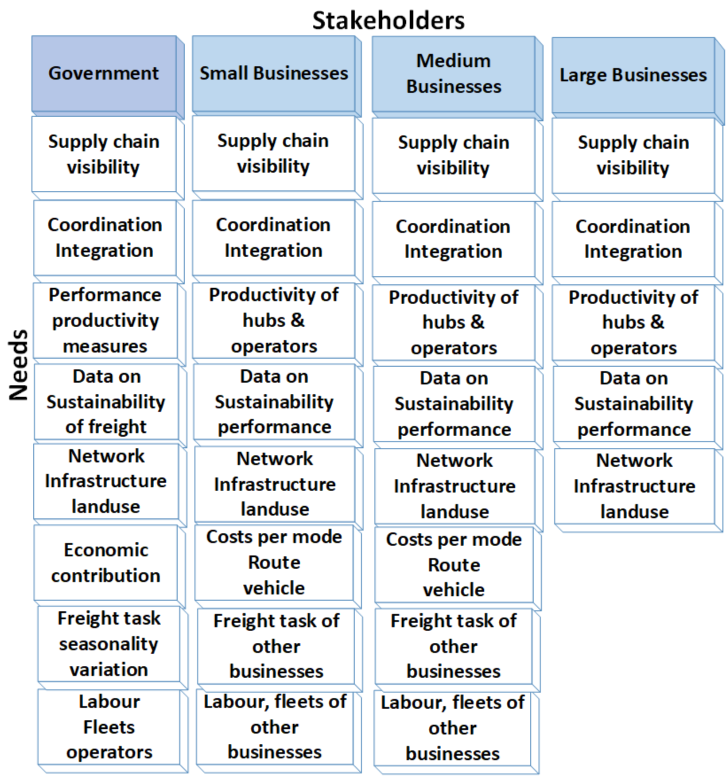


Table 4-1: Top gaps identified, by main gap classification

No.	Gap Classification (in order of significance based on applying methodology)	Example 1	Example 2
1	Supply chain visibility	Visibility of containerised supply chain	Visibility of food and manufactured products supply chain
2	Integrated coordination schemes	Lack of coordination, interoperability & integration of freight operators and stakeholders in the import/export trade through ports	Lack of coordination and integration of urban goods and services transport
3	Freight tasks	Regular and updated commodity-based freight task for all transport modes	Lack of enough granularity of freight task
4	Productivity measures	Productivity measures of trucking companies and rail operators	Standardisation of productivity measures
5	Labour, fleet, operators	Information about the number of labour per fleet, skills and age	Utilised fleet separately for ancillary and for-hire operators
6	Network Infrastructure/ Land use	Data about the first mile, last mile issues of network	Network resilience and integration of this data with modelling and planning
7	Cost/revenue and economic contributions	Commodity-based and region-based operational cost for all transport modes	Cost and quantity of inefficiencies in each element of the supply chain (eg. cancellation fees, invalid PRAs, extra trips, etc)
8	Sustainability measures	Sustainability indicators of transport modes and logistics nodes	Impact of regulations to improve sustainability (ie. before-after studies of imposed regulations)

Table 4-2. Data gaps, causes, and benefits from eliminating gaps

Area	Data gap / limitations	Causes / barriers	Benefits for private sector / short-term	Benefits for private sector / long-term	Benefits for government sector / short-term	Benefits for government sector / long-term	Benefits for public	Solutions/ recommendations
Supply chain visibility (1)	Lack of visibility for commodities except for a few cases	Implementation cost which is borne by the private sector Difficulty in technology adoption by small businesses Data confidentiality issues if the project is monitored by government or third-party Engaging the private sector by the government is a hurdle	Increasing productivity by minimising the operational costs Assisting the operational and tactical planning (labour, fleet management) Increasing customer satisfaction by providing track and traceability	Assisting the tactical and strategic planning Informing policy makers by evidence-based data about the necessary investments	Collecting robust freight data more efficiently compared to surveys Covering other data gaps such as freight task, fleet, infrastructure bottlenecks, costs and revenues	Identifying the bottleneck and inefficiencies assist in strategic planning and investment plans Increasing Australia's economic competitiveness by supporting exporters and businesses	The fast and traceable delivery system Reduced cost for the end-user as a result of optimisation Foreseeing the future trend, creating opportunities for app-developers and innovative ideas and having a long-term profitability	Standardisation with GS1 has been piloted; TraNSIT also has been applied for agricultural commodities. These projects can be expanded by providing incentives for the private sector such as subsidising the registration cost or fuel, and/or implementing an integrated encrypted and distributed ledger technology to provide trust and confidentiality
Integrated coordination schemes (2)	Only a few examples exist	Implementation cost Difficulty in technology adoption and changes in business model structure	Increasing productivity by optimising the operations, manual works, disputes Assisting the operational and	Historical data collection hence assisting the tactical and	Collecting robust freight data consistently and efficiently including freight task,	Historical data collection in a consistent and integrated way Increasing Australia's economic	Reduced cost for the end-user as a result of optimisation Foreseeing the future trend, creating	Pilot project to provide the evidence-based benefits and proof of concept for the industry Implementing an integrated encrypted and distributed ledger

Area	Data gap / limitations	Causes / barriers	Benefits for private sector / short-term	Benefits for private sector / long-term	Benefits for government sector / short-term	Benefits for government sector / long-term	Benefits for public	Solutions/ recommendations
		Data confidentiality issues if the project is run by government or third-party Engaging the private sector by the government is a hurdle	tactical planning (labour, fleet management) Increasing customer satisfaction by providing faster services and traceable information	strategic planning Long-term productivity	fleet, infrastructure bottlenecks, costs and revenues	competitiveness by supporting freight transport companies, exporters, businesses, port and rail	opportunities for app-developers and innovative ideas and having a long-term profitability	technology to provide trust and confidentiality for businesses
Freight task	Siloed and un-harmonised freight task data Lack of updated freight task based on the commodity by air and rail The level of granularity is not satisfactory for modelling and planning purposes	Huge cost of data collection Dispersed organisation providing data Data of private sector is not easily accessible	Small businesses can compare their undertaken task with others		Benefit-cost analysis of investment projects and infrastructure projects appraisals	Strategic investment planning and regulations		Close collaboration between various data providers (ie. national and state-based governments) Foreseeing a procedure to obtain productivity measures after privatisation, and/or revising the existing procedures

Area	Data gap / limitations	Causes / barriers	Benefits for private sector / short-term	Benefits for private sector / long-term	Benefits for government sector / short-term	Benefits for government sector / long-term	Benefits for public	Solutions/ recommendations
	Lack of data on seasonal variation in freight task							
Productivity measures	Lack of productivity estimates for ancillary road operators Inconsistent definitions of productivity The existing measures are limited to partial productivity with only one or two factors	Difficulty in obtaining data from private businesses	Businesses can compare their undertaken task with others Assisting in the operational planning	Strategic investments and planning	Tactical planning and infrastructure projects appraisals	Strategic investment planning and regulations		Standardisation of definitions of productivity measures Foreseeing a procedure to obtain productivity measures after privatisation, and/or revising the existing procedures
Network, infrastructure, land use	Lack of data on network resilience Lack of data on rural roads and first-mile/last-mile issues	Lack of integration leads to siloed data at the local councils and governments which do not necessarily feed the strategic models	Informing policy-makers about everyday operational issues of exporters/importers, farmers and private businesses	Long-term benefit as a result of investments and network improvements	Assisting in tactical investment planning More accurate models as a result of integration	Assisting in strategic investment planning Increasing Australia's economic competitiveness	Reduced cost for the end-user as a result of less loss/damage/issues	An inclusive work groups from all stakeholders

Area	Data gap / limitations	Causes / barriers	Benefits for private sector / short-term	Benefits for private sector / long-term	Benefits for government sector / short-term	Benefits for government sector / long-term	Benefits for public	Solutions/ recommendations
	Lack of after-studies of infrastructure projects Lack of integration of land use planning and freight transport models				with land use data	by improving network issues/bottlenecks for the exporters/importers, private businesses		
Labour, fleet, operators	Lack of data of labour for freight transport Lack of data on labour per fleet Lack of data about ancillary and for-hire operators in road freight Lack of issues around labour such as aging,	Difficulty in obtaining data from private businesses Data confidentiality issues		Providing the supply for skilled labour as a result of government planning	Providing input for productivity measures	Strategic planning for labour supply, foreseeing training needs Providing input for transport Satellite account	Increasing satisfaction of labour in freight transport by solving some issues such as lack of gender diversity or pay gap	An inclusive work groups from all stakeholders and associations

Area	Data gap / limitations	Causes / barriers	Benefits for private sector / short-term	Benefits for private sector / long-term	Benefits for government sector / short-term	Benefits for government sector / long-term	Benefits for public	Solutions/ recommendations
	skills, required training							
Sustainability measures	lack of information on environmental impacts of freight task by transport modes not enough sustainability studies and						Increasing the liveability of cities and precinct around freight activities Reducing the environmental impacts on climate change and ecosystem by encouraging the	

Area	Data gap / limitations	Causes / barriers	Benefits for private sector / short-term	Benefits for private sector / long-term	Benefits for government sector / short-term	Benefits for government sector / long-term	Benefits for public	Solutions/ recommendations
	action plans with regards to freight transport system						sustainability of freight system	
Cost/revenue and economic contribution	Lack of mode, commodity-based cost/revenue metrics Lack of cost data of air freight	Cost data is commercially sensitive Businesses provide a range of rate for different customers	Opportunities for cost-benefit analysis and modal shift		Cost-benefit analysis for the infrastructure project appraisals	Strategic planning Providing input for the transport Satellite account		

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