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Freight modelling in Australia in 2021 – A data availability perspective

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Abstract

Despite the fact that freight and commercial vehicle movements are expected to grow at a fast rate in the next couple of decades in Australia, the existing freight modelling components for the majority of Australian cities is lagging substantially behind their personal travel counterparts and no statewide or nationwide models are openly available for planning of infrastructure and scenario analysis.

In this paper, we analyse the freight data availability and discuss their suitability for the development of freight models in Australia. A comparison was also made against data and modelling advancements in both the USA and Europe.

1. Introduction

BITRE predicts that the total freight task in Australia will grow by 25% from 770.4 billion tonne kilometres (tkm) in 2018 to 962.5 billion tkm in 2040. Figure 1 illustrates how freight transported by rail makes up the greatest proportion of tonne kilometres travelled (mostly minerals), comprising of 57% of the total in 2018. BITRE predicts that the greatest growth will occur in road freight which is predicted to grow by 25% from 216.3 to 337.4 billion tkm.

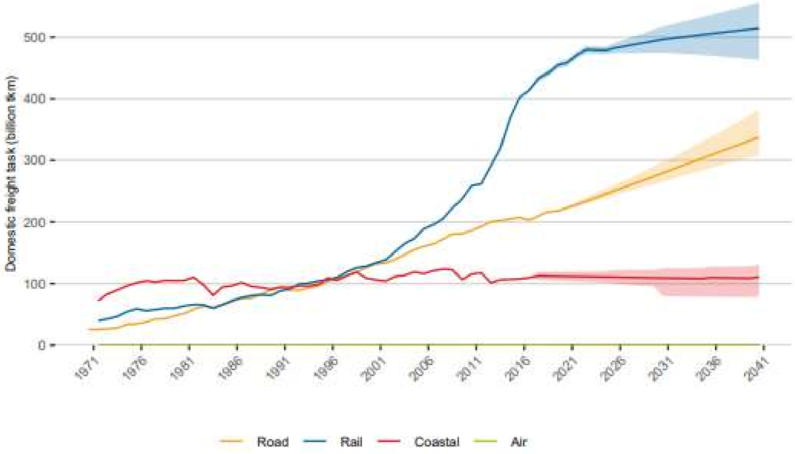

Figure 1: Projected future freight task in Australia, by major transport mode (source: BITRE)

In parallel, the urban end of the freight task, goods movements to the end consumers, is changing fast and increasing in complexity. For example, online shopping has increased by more than 5% year on year[1].

Despite the magnitude and significant expected growth in the Australian freight task, State transportation departments and other public agencies often do not have freight forecasting tools at their disposal capable of analyzing relevant scenarios for the impact of future freight movements on their transportation networks, population and the environment.

The absence of robust freight models can be partly attributed, however, to irregular and inconsistent collection of data and hence poor availability of useful statistics on freight movements across the country. In some cases where good data is collected, such as by shipping agencies or logistic companies, it is not able to be accessed in its entirety due to its proprietary or confidential nature. Despite the existence of a few good available data sets, a quick exercise of mapping all of them to the transportation models for which they could be the basis for estimation reveals significant gaps, as this paper further explores in the context of both more traditional and more advanced models.

It is well known that developments in freight models lag significantly behind passenger transport models, not only in Australia but all over the world, and that a key contributing factor for this is lack of suitable data (Camargo and Walker, 2017, Elaurant et al., 2007). Motivated by the authors' efforts to compile data sources available to inform a model able to forecast the movement of goods and servicing vehicles in Queensland, the objectives of this paper are to:

- Provide an overview of key available data sources available in Australia
- Provide an overview of freight modelling approaches including how to represent the different actors in freight demand
- Identify the main data gaps for the development of a simple commodity-based freight model and to indicate how that gap would increase in the case of a state-of-the-practice model
- Make a plea for a set of freight-specific surveys that would enable solid freight models to be developed

2. Key available data sources

Following an extensive review of open data available to inform the development of a freight model in Queensland, the authors identified several potentially relevant data, most of which are relevant countrywide. As summarizing these datasets involved short incursions into the data and its documentation, it was possible to start an exploration of the potential uses of each data source in different model components of increasing complexity. As significant data gaps became apparent, however, we have decided to focus this paper on these gaps in the context of a simple model structure. While this process was undertaken for data sources in Queensland, it can be generalized to other states in Australia.

As shown in Table 1, we have identified 42 potentially relevant data sources for the case of Queensland, but many other redundant data sources were also found during the data review process. In most cases data sources were considered redundant if they did not contain additional information to that provided by one or more of the listed data sources. Other data sources had limited usability as they could not be directly linked to the actors in the freight system, for

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[1] https://auspost.com.au/business/marketing-and-communications/access-data-and-insights/ecommerce-trends

example, the Queensland Household Travel Survey which is focused on individual rather than commercial travel.

Aside from two examples, all other datasets fit three distinct groups:

- Focused on the economics of commodity production rather than transportation
- Extremely spatially and commodity-wise aggregate to the point of adding no value to model estimation
- Data on relevant explanatory variables only

This first group of datasets include a vast number of Input-Output tables which, although important for purely economic analysis, have not found a place in modern freight transportation modelling, as evidenced by the lack of literature on their use in practice. A key challenge of this type of model is finding reliable factors that convert dollar values of trade flows into tonnes of commodity flows, let alone mode-specific movements such as truck flows.

The second group of data sets includes data such as trade statistics, and agricultural and mineral production statistics, which cover well the production and consumption of commodities and are extremely relevant for the initial demand generation stage of a freight model, although availability is inconsistent across commodities.

The third group includes data sources that may be relevant as explanatory variables or control totals at various modelling stages. This group includes, but it is not limited to, the count of Australian businesses, land use information, building footprints and surveys of motor vehicle use. Although relevant, these datasets are only a small portion of the data necessary for model estimation.

In general, it has become clear that there are few detailed datasets on the total freight movements for commodities, as well as virtually no data on freight movements and their interaction with the logistics systems in place. The only exception to the latter is the 2014 ABS Road-Freight Survey, which we discuss in a little more detail.

Table 1: Data summary of available sources for Queensland

Data Source	Data Type	Spatial resolution	Temporal Resolution	Mode	Commodity
Survey of Motor Vehicle Use, Australia	Aggregate Statistics	National, by state of registratio	Yearly	Truck	N.A.
Queensland Agricultural Snapshot 2018	Agricultural statistics	State	Yearly		Broad agricultural groups
Agriculture: Gross value of production by commodity, Queensland	Agricultural statistics	State	Yearly		~30 commodities
Livestock Products, Australia	Agrobusiness - Livestock production statistics	State	Quarterly		Livestock Products
Australian Sugar Milling Council: Sugar Industry Summary Statistics	Agrobusiness - Sugar industry summary statistics	National, state-wide, specific a	Yearly		Sugar
Australian Business Register	Business microdata	location of individual businesses (post code at a minimum)	Point in time		
2014 Road Freight Movement Survey	Commodity Flows	SA3	Yearly	Road	23 commodity group
2001 Freight Movement Survey	Commodity Flows	Aggregate Statistical divisions	Yearly	Road, Rail, Sea and Air	broad commodities
Value of Agricultural Commodities Produced, Australia	Commodity production statistics	National, State, SA4	Yearly		~80 agricultural commodities
Agricultural Commodities, Australia	Commodity production statistics	SA4	Yearly		~300 types of commodity dissagregation
Victoria University Regional Model (VURM)	Economic Model	statistical level of aggregation	Yearly		79 industries producing 83 commodities
Building areas - Queensland	Building location data	Building locations	Point in time		
Geoscape Buildings	Building location data	Building locations	Point in time		
Dspark	Geo-spatial temporal mobility data	National	unknown	Road	
Location-Based services	GPS traces	Point	Second		
QFM Feature Points	Point of interest data	Point of Interest	Point in time		various
Queensland Land Use Mapping Program (QLUMP)	Point of interest data	Detailed land use parcels	Point in time		
OpenStreetMap: Australia	Spatial layers	Point and Area	Point in time		
Australian System of National Accounts (Table 42. Household final consumption expenditure)	Household final consumption expenditure	National	Yearly		~ 60 goods and services
5216.0 - Australian National Accounts: Concepts, Sources and Methods, 2000 (Table 1. Australian production by product group by industry)	IO	National	Yearly		~ 114 product groups
5216.0 - Australian National Accounts: Concepts, Sources and Methods, 2000 (Table 2. Input by industry and final use category and imports by product group)	IO	National	Yearly		~ 114 product groups
5220.0 - Australian National Accounts: State Accounts, 2017-18	IO	State	Yearly		
Australian System of National Accounts	IO	National	Yearly		
Australian System of National Accounts (Table 50. Agricultural income, current prices)	IO	National	Yearly		~ 25 commodities
Labour Force, Australia, Detailed, Quarterly	Labour force statistics	State	Quarterly	NA	NA
Economic Activity: Queensland State Account	Macroeconomic statistics	State, National	Quarterly, Yearly		
8165.0 Counts of Australian Businesses – employment and turnover by size range – state by industry class (INDP4) and SA2 by division (INDP1) (for allocation within state in B4).	Macroeconomic statistics	SA2, LGA	Point in time		
8502.3 - Interstate Trade, Queensland	Macroeconomic statistics	State	Quarterly		~26
8155.0.003 Manufacturing Industry – wages, sales and value-add by industry class	Macroeconomic statistics	National	Yearly		~25 commodity categories, 95 total expenditure categories, including services
8155.0.002 Australian Industry – national income, expenditure and economic value by industry subdivision , wages and sales by industry division by state	Macroeconomic statistics	National	Yearly		
Agricultural commodities and trade data	Macroeconomic statistics	National	Yearly		~20 commodities
5215.0 - Australian National Accounts: Input-Output Tables (Product details)	Macroeconomic statistics	National	Yearly		~ 114 product groups
The Census of Population and Housing, 2016	Population and housing statistics	LGA, CED, SSC, SA1, SA2, POA, GCCSA, UCLs, SUAs, Ras, ILOC, IARE, IREG	Quadrennially		
Census - Place of work	Population statistics	SA2	Point in time		
Census - Industry of Employment	Population statistics	SA2	Point in time		
Open data - mineral and energy resources	Production data for mining and resources	Various	Yearly		Various mineral and energy resources
Retail Trade, Australia	Retail trade statistics	State	Monthly		
Trade Statistics for Queensland Ports	Trade statistics	By Port	Yearly	Sea	14 of Queensland's main commodities
Australian National Accounts: Input-Output Tables	Trade statistics	National	Yearly		~90 product groups
Merchandise exports and imports country and commodity by State and Territory	Trade statistics	State	Yearly, Monthly		commodity and merchandise groups– available by SITC, TRIEC and AHECC/TRIEC
ABS 5368.0 International trade in goods and services, Australia	Trade statistics	National	Monthly		~13 product groups
Queensland Household Travel Survey Series	Travel Survey	SA1	One year		

Besides data availability itself, commodity aggregation has proved to be inconsistent across different data sources, with levels of detail being vastly different depending on the data source examined.

2.1 Freight movement surveys

Despite the abundance of aggregate data for the production, consumption, import and export of commodities and the economy more broadly, little is available when it comes to commodity flows besides the 2014 Road Freight Movement Survey (RFS) and the 2001 Freight Movement Survey (FMS) from the Australian Bureau of Statistics (ABS).

The 2014 RFMS provides estimates of freight moved by road for the period 1 November 2013 to 31 October 2014. The statistics are based on a sample survey of articulated and rigid vehicles that were registered with an Australian motor vehicle registry during the collection period, excluding defence force vehicles. In the surveys, the respondents were asked to record the origin and destination of their most recent trip. Movements involving multiple modes of transport were recorded separately e.g., freight moved from Sydney to Hobart would be recorded as two separate trips as the component by sea was outside the scope of the survey. This also resulted in Tasmania having nil interstate road movements. As highlighted in Table 1 the 2014 RFMS contains estimates of origin to destination flows by method of transport, trailer configuration and commodity type and weight by laden and unladen tkm travelled for different spatial disaggregations.

The 2001 FMS encompasses similar information on road movements as well as those by air, sea and rail. The road freight component focusses on articulated vehicles only and employed different sampling techniques thus is not directly comparable to the 2014 RFM database.

An obvious limitation of this data is that it does not contain up to date information, especially for freight movements by non-road modes. The ABS has indicated[2] that it does not have plans to conduct similar surveys in the future and a key question is therefore whether this data has residual value; alternatively if this information can be obtained or proxied in another way.

From a modelling perspective a key limitation is that the data set contains trip based data and does not give us information about whether movements are between production and consumption zones, or if they are between intermediate points such as warehouses, limiting the value of such dataset for the development of more advanced models, as will be further discussed.

2.2 International comparison

For the sake of comparison, we examined datasets that are most often used in freight modelling in the USA, which include both free and paid datasets.

The most important of all readily available datasets is the Freight Analysis Framework (FAF) (Hwang et al., 2016). Developed by the Oak Ridge National Laboratory for the US Department of Transportation, FAF is a comprehensive view of freight movements throughout the USA covering all commodities and transportation modes (including multimodal).

Despite its low spatial resolution (~140 zones plus ports, airports and international gateways), FAF provides consistent control totals for overall production, movement patterns and mode splits. Other data sources, such as T-100 database on airline flows at flight segment level, the geospatial classification of crops at high resolution provided by CropScape(Han et al., 2012),

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[2] Personal communications

as well as the confidential Railroad Waybill and the Commodity Flow Survey (CFS), provide most of the tools necessary to create robust freight models that can have each one of its outputs properly validated.

There are also many reasonably inexpensive datasets available for the entire country, such as detailed records on businesses, including time-series for business life cycles (Dun& BradStreet, NETS) and large datasets of truck GPS data from the American Transportation Research Institute (ATRI).

Among the more expensive datasets used in freight modelling in the USA is TRANSEARCH, which is a comprehensive dataset of freight flows at a much more detailed level than FAF. This dataset, however, is considered a synthetic dataset, and very few details on its development have ever been made public.

Finally, many other data providers, such as StreetLight Data, INRIX, HERE and TOMTOM, also have relevant datasets on truck movements available for purchase, although there are fewer examples of their use in the literature.

There is also an extensive literature on freight data in the USA, particularly on the outcomes of the Strategic Highway Research Program 2 (SHRP2) freight demand modelling and data improvement (C20)[3], which cover all relevant aspects of freight data with respected to modelling in the USA.

3. Freight models and main data gaps

When discussing the differences between existing types of freight forecasting models, it is worth keeping in mind the layers of decisions that exist in the system driving freight demand, as there are many different factors that influence the production, consumption and trade of goods, the logistic network, and the organization of transport (Tavasszy and De Jong, 2013) (de Dios Ortúzar and Willumsen, 2011).

These processes are continuously changing and evolving, driven by developments (Meersman and Van de Voorde, 2019) that can be grouped into several categories, including evolutions in the commodity market, political decisions, changes in market conditions and exogeneous developments such as climate change and developments in technology. Freight models should in principle be sensitive to these developments so that they can be used to represent their impact on the system being modelled.

Production and consumption are the easiest layers in a supply chain to discuss, and it involves the actors that influence the demand and supply of goods and spatial organization of the movements of goods. This includes producers who make decisions on the deployment and location of production factors (e.g., land, labor) and consumers who influence consumption patterns and shipment size.

The logistic network and supply chain decisions influence spatial patterns and volumes of trade, storage and the (de)consolidation of flows that may occur at intermediate locations. Decisions made in this layer are aimed at keeping costs low, for example by maintaining proximity to markets. The final layer is organization of transport which includes the choice of mode, vehicle type, trips and route.

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[3] http://shrp2.transportation.org/Pages/Freight-Demand-Modeling-and-Data-Improvement-(C20).aspx

These layers are not independent from each other, however. For example, the optimal shipment size may depend on the cost of transport, which is dependent on mode, where the optimal mode may depend on the shipment size.

Freight models capture the different actors and their interactions to varying degrees, decisions on what actors are included are based on data availability and the focus of the model. For example, (Boerkamps et al., 2000) describe one type of change that impacts freight flows as ecommerce that changes the temporal and spatial distribution of consumption. A model that is able to assess the impact that e-commerce has on infrastructure needs and emissions must capture the changes in behavior with respect to production/consumption of goods, interactions with the distribution system and the impact of public policies on all of those elements, such as the limitation of delivery hours or vehicle size for city-centre deliveries.

When it comes to modelling these complex systems, the most commonly utilized method is an adaptation of the traditional four-step approach, which was initially developed for modelling personal travel, and remains very common in many of the freight models in Europe (De Jong et al., 2013b). Although many of the policy questions asked these days by planners and elected officials require more advanced models, the four-step approach is sufficiently well known to be used as a reference when looking into data gaps.

However, although four-step models are useful as a reference, the actual processes and interactions in freight systems are more complex, and therefore any future model implementation should focus on more advanced, more relevant, model structures found in the literature and implemented elsewhere.

On this note, we have decided to limit the analysis presented below to very objective data gaps and frame the discussion from the point of view of the first three steps of the traditional four-step modelling approach with some common adaptions specific to freight.

3.1 Generation (Production/Consumption)

(De Jong et al., 2004) outline the key approaches to estimate the volumes and monetary value of commodities transported from origins to destination zones as trend and time series, models, system dynamic models, zonal trip rate models and models related to I/O tables.

In Australia, a primary source for commodity-specific information resides in the imports and exports records, while industry-specific data sources also provide information in enough detail for the spatial allocation of commodity production and, to a similar degree, commodity consumption.

There is not, however, a source for total production and consumption of commodities (or commodity groups) for the vast majority of commodities, making it hard to fully validate any freight generation model even at its most aggregate form.

It is possible that other institutions in Australia, such as Bureau of Infrastructure and Transportation Research Economics (BITRE) and CSIRO, may have the data necessary to positively validate freight generation models, but that has remained uncertain during many freight modelling related efforts by the authors.

3.2 Distribution (Consumer/Supplier association)

The trip distribution (or consumer/supplier association) step of a simple freight model consists of modelling the pattern of flows between origins and destinations once productions and attractions are known.

These patterns, especially in statewide contexts, are substantially more complex than those observed in urban personal travel models and are influenced by unobserved commodity-specific variables such as market structure and network characteristics, such as the existence of rail terminals or ports near origins/destinations. The distribution step is further complicated by warehousing, stockpiling and distribution centers which often result in additional detours between locations of production and consumption. For this reason, model structures used in the past, particularly synthetic gravity models (de Dios Ortúzar and Willumsen, 2011), fail to adequately capture the real trip distribution patterns into its model parameters.

Filling this gap, destination choice models, even in their aggregate interpretation as the fractional split model (Sivakumar and Bhat, 2002), allow greater control of detail in terms of zonal variables and transportation costs.

In order to estimate destination choice models, or even gravity models for that matter, it is necessary to have information on flows between origins and destinations, be that from dedicated surveys, or from existing commodity flow matrices.

Covering exactly this space, the 2014 ABS Road Freight Survey (RFS) is a comprehensive, nationwide view of truck-based commodity transport, and it is adequate for the estimation of a fractional split model. Having said that, an important caveat with regards to the content of this data set needs to be noted when utilizing it for the estimation of destination choice models. As it turns out, the 2014 RFS was a survey of truck movements, and NOT of commodity movements, meaning that it not only excludes all flows by rail, water, pipeline or air, but it also represents different legs of road transport and the flows to/from other transport terminals as independent flows. As a result, commodity flow distance will be biased downwards which would, in application, result into an artificially uncongested network.

It should also be highlighted that, as discussed in Section 2.1, the ABS has indicated that it does not have immediate plans to undertake a more recent version of this survey. While it was undertaken what is already seven years ago, there is no reason to believe that the current freight flow patterns have changed so much that the data can no longer be used for estimation, although careful selection of contemporary explanatory variables would be recommended. Short-term forecasts for a more recent year and benchmarking against the literature would also be ideal, as recent changes in urban freight patterns and logistic systems have been well documented in the literature (Kang, 2020).

If there are reasons to believe that freight patterns have significantly changed since 2014, there would be no currently available data sources to inform freight movement patterns between production and consumption zones.

Finally, the fractional split approach is nearly 20 years old, and some reflection on whether it is reasonable that the best we can do in Australia (with publicly available data) is to use technology that old, while failing to take advantage of a swath of newer developments in both USA (Southworth, 2018) and Europe (de Jong et al., 2013a) (Jensen et al., 2019) in that period.

3.3 Mode Choice

At its most basic level, mode choice involves the shipper's decision as to what mode should be used to deliver the goods to their destination. In such a model, the shipper chooses the mode to minimize the perceived (stochastic) cost of sending the consignment (ignoring the impact of shipment size and other similar issues on transportation cost for now).

Mode choice models are also a key component of transportation models, as many transportation policies aim to move demand from less efficient modes to higher capacity/higher efficiency modes. In the case of freight transport, one of the most common objectives for transportation policies and investments is to move truck flows onto rail, so we need to properly understand and model the drivers that make shippers choose one of these modes over the others.

Data on how shippers make their choices between different modes can exist in different forms, from detailed information on a large number of shipments across the entire modelled area, to aggregate information on mode shares by OD zone.

Despite the many forms that observed mode choice could take, there is currently no openly available data set in Australia to support the development of mode choice models for commodity-based freight models, apart from very aggregate information from BITRE reports that are insufficient for the development of robust and useable models.

3.4 Advanced model components

Although the above analogy with four-step models illustrates that it is trivial to identify the main data gaps that one would find when trying to estimate a simple freight model, we have already pointed to the fact that the current needs in freight policy analysis would require much more sophisticated models which are also in existence elsewhere, representing what we consider current best practice.

When looking into the current state of practice in commodity-based freight models, we see that they are often highly detailed and often micro-simulated, following in the development footsteps of personal travel models. These techniques elevate models to what can be classified as behaviour-based approaches, transforming distribution models into supplier-selection models (Pourabdollahi et al., 2017), and mode choice models into logistic-path choice models (Stinson et al., 2017).

Other model components tackling the specifics of urban flows and aiming to model the exponential growth of e-commerce and its associated logistics processes have also emerged, notably truck-tour models (Kuppam et al., 2014).

These and many other more advanced freight model components have substantial additional data requirements, however, and aggregate data such as the 2014 RFS may not be sufficient for the development of most of them.

3.5 Data gap summary

After reaching the conclusion that there is no data set publicly available in Australia for the development of even quite simple freight models, one needs to decide how to proceed when incorporating a freight component in forecasting models.

The first solution for this problem is to limit all freight modelling to a commodity-based truck model based entirely on the 2014 RFS, although that solution will become progressively less appealing as time advances and the survey results becomes less relevant for reflecting base year conditions.

The second solution is to proceed to large-scale data collection or to seek partnerships with institutions that might already have the necessary data (e.g. BITRE, CSIRO). In this scenario it is reasonable to proceed to a careful inventory of the policy analysis requirements for a potential model, as well as a detailed specification for said model before any data is procured, as data collection efforts and their cost might become a major constraint for such efforts.

In general terms, however, State transportation agencies looking into developing new advanced freight models can expect that conducting a commercial establishment and vehicle survey, including the collection of truck GPS data, should address the vast majority of their data requirements.

It should be noted, that the lack of appropriate data for freight planning would be much more efficiently solved at a nationwide level, as the USA has shown with the unquestionable value provided by the Freight Analysis Framework, now in its fifth version, over two decades after its first release.

Government agencies are beginning to take steps to address this shortfall in country wide freight data through initiatives such as the National Freight Data Hub[4]. In May 2021, the Australian Government committed $16.5 M over four years[5] to establish the Hub which aims to work with industry to make freight data more open and available, as well as push for the adoption of consistent data standards.

4. Conclusions

In this paper we have mapped currently available data sources to a simple generic freight model structure for which they could be the basis of estimation. From this exercise we have identified that there currently is not sufficient data to inform a traditional four-step style freight model, let alone the data required to inform the more advanced, data intensive models that are needed to answer current policy questions (such as the impact of freight and commercial flows on urban centers and the performance of policies aimed at minimizing the impact of last mile deliveries - which are typically high in cost - and freight-generated impacts on environments and surrounding communities (Macioszek, 2017, Bosona, 2020)). This task is likely to become increasingly challenging with the termination of data sources such as the ABS Survey of Motor Vehicle Use.[6]

For this reason, any jurisdictions interested in developing freight models capable of responding to contemporary policy and infrastructure questions would most likely need to undertake additional and specialized data collection/acquisition efforts. Designing and conducting these surveys takes time; and in parallel building know-how in agencies and among consultants is required, so time is of the essence. Australia lags behind the USA and Europe. Given the national aspect of freight movements and the benefits that the country could reap from the synergies between investments in different States, it would be ideal if such freight data would be collected at national level and subsequently be made available through platforms such as the National Freight Data Hub.

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[4] https://datahub.freightaustralia.gov.au/

[5] https://www.infrastructure.gov.au/transport/freight/national-freight-data-hub/index.aspx

[6] https://www.abs.gov.au/statistics/industry/tourism-and-transport/survey-motor-vehicle-use-australia/latest-release

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