Business-as-Usual Model Road Freight Transport Emission

Project Review and Closure Report

Industry Exchange

Western Roads Federation

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Executive Summary

Australia is committed to taking actions for reducing the carbon footprint to 43% of 2005 performance by 2030 and aims to ensure emissions are equal to the amount removed from the atmosphere in 2050 [1]. While significant attempts are being made to limit output levels of greenhouse gas in the transport sector, emissions remain a major concern for transporters, investors, customers, consumers, and governments alike. Many studies have been conducted to determine the factors and methods that influence the calculation of carbon emissions in the transportation sector. However, these studies are constrained to the national or state levels.

The current work will bridge this gap by conducting a total emission methodology in freight transport under a business-as-usual (BAU) scenario based on the activity projection and emission intensity projection. This study analyses data from 2001-2020 (net tonne-kilometre, population growth, per capita income levels, road freight costs and average load carried) and focuses on different various geographic regions across Australia and targets freight vehicles. The findings of this project help regulators understand the factors that influence the growth of total emissions. As a result, policymakers can evaluate the effectiveness of regulations in each region across the state. They can optimize the implementation of policies to reduce emissions thoroughly. Various recommendations are proposed to help develop this methodology further to achieve more accurate results in evaluating the effectiveness of policies.

Acknowledgement

I would like to express my sincere gratitude to those who have contributed to the successful completion of this project.

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DOCUMENT ACCEPTANCE

This Business-as-Usual Model Road Freight Transport Emission Review and Closure Report is authorised for release once all signatures have been obtained.

PREPARED: ______________________________ DATE: __________

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ACCEPTED: ______________________________ DATE: __________

(for release) (Cam Dumesny, Western Roads Federation)

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1. Introduction

1.1 Background

The freight transport sector today remains one of the economic engines that drives commerce in Australia and sustains employment for over a million people [2]. Around 4 billion tonnes of goods are being delivered across the country yearly, an estimate of 163 tonnes of freight per each person [3]. Considering the country's size, population spread and economic factors – domestic freight is a critical sector, that the country heavily relies upon. In 2020-2021, according to Australian Bureau of Statistics (ABS) [2], the total transport activity contributed 7.9% ($164.4 billion) to the century's GDP.

Despite the substantial figures, the freight task is expected to continue increasing and double by 2030. With the rising demand on transportation systems, more government and industry attention are being focused on growing environmental impacts that freight transport brings [4].

As a well-known fact - greenhouse gas emissions pose a global challenge, where Australia is accountable for around 1% of the total world emissions [5]. The Quarterly Update of Australia's National Greenhouse Gas Inventory for March 2024 shows that 440.2 million tonnes of carbon dioxide equivalent (Mt CO_2) were emitted over a year [6]. The transportation industry stands as one of the top factors in Australia impacting greenhouse gas emissions - 21% of total in the country, of which 42% come from freight transport, including Light Commercial Vehicle, Rigid Truck and Articulated Truck [7], additional 42% from passenger cars, 4% from rail transport and 12% from other sources. In fact, rail transportation produces 16 times less carbon pollution per tonne kilometre than road freight, displaying the need for refinements in the road freight sector.

The Australian Government has implemented a significant number of policies to reduce emissions. The New Vehicle Efficiency Standard was introduced in January 2025 to regulate carbon dioxide emissions from new vehicles in Australia [8]. Additionally, Australian fuel quality is regulated to limit the use of poor-quality fuels that affect the environment and damage the life of vehicles [8]

Despite various efforts, Australia's emissions are 28% below 2005 in 2024 [9]. To achieve Net Zero by 2050, the Australian Government must consider the performance of existing policies and evaluate their effectiveness to ensure that the target is achieved as planned [10].

1.2 Literature Review

Since the 2015 Paris Agreement, there has been a global surge in research efforts aimed at achieving Net-Zero emissions by 2050, including Australia. The focus to solve this challenge has never been stronger, bringing more researchers, innovators and policymakers together join the effort each year.

An important work in the field is the "Australian aggregate freight forecasts – 2022 update" by the Bureau of Infrastructure and Transport Research Economics (BITRE). The update provides a deep analysis into latest trends and estimates of Australia's freight dynamic for the previous and next decades across major transport sectors (air freight, rail freight, road freight, etc).

Focusing on the Road Freight, the largest contributor of CO_2 emissions in the transport sector [11], BITRE has developed a single-equation econometric model for forecasting the national road freight activity. The model uses a log-linear regression to estimate the relationship between road freight task (road freight per capita measured in tonne-kilometres) and key economic factors, with primary being the Road Freight Costs and Australia's per capita real Gross National Income (GNI). The method helps capture how changes in economic conditions influence freight activity across the country by the Equation 1:

$$Freight\ Per\ Capita = -18290.8 + 7525.865 * log(GNI\ Per\ Capita) - 2157.340 * log(Freight\ Rate) - 612.551 * D_{PostGFC} - 203.953 * D_{1991} - 207.555 * D_{COVID} + \varepsilon$$

Australia's historic data was used to fit the model and achieve the Equation 1. The visualization of the historical and projected road freight activity in Australia are displayed as a line chart on Figure 1. According to BITRE, 241.8 billion tonne-kilometres of freight was transported by road in 2022-2023, aligning with BITRE's projections, which generally indicate a consistent upward trend in road freight activity [12].

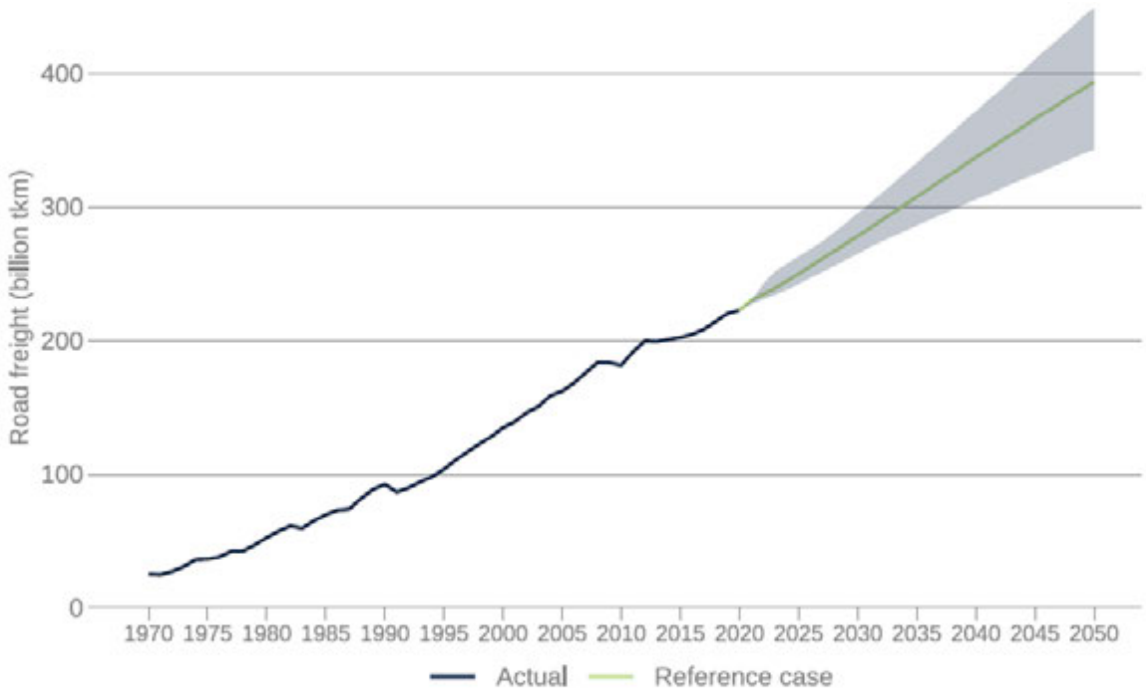

Figure 1. Estimated Freight Per Capita dynamics over the timeline of 1970-2020 and forecast for years 2021-2050. Source: "Australian aggregate freight forecasts – 2022 update" by the Bureau of Infrastructure and Transport Research Economics [11]

According to Australia's Emissions Projections Methodology, the activity projection will be integrated with an emission intensity projection to project total emissions [13].

While the report offers in-depth research, including insights and projections, for the road freight sector, there are gaps yet to be addressed. In addition, the emission projection accounts for national level data and estimates only. The deviation for important factors such as vehicle types, states and regional urbanization levels are left out.

Each state region has unique characteristics and requires different policies to be implemented. According to National Heavy Vehicle Regulator, there are many differences in the dangers of travelling on rural and regional roads, such as speed limits or environmental differences [14]. Firstly, the maximum speed limit in rural areas in the Western Australia is 110 km/h, while in densely populated areas, the maximum speed limit is 50 km/h [15]. In addition, regional areas will have more environmental challenges, such as animals or visual obstructions, which can cause traffic accidents. These differences need to be considered when developing policies for individual regions. As a result, regulations cannot take a one-size-fits-all approach to Australia; the government should focus on different geographic levels across state to maximize the benefits of the regulations [16].

Currently, The Australian Truck Association (ATA) has a package of feasible measures to support freight transport to reduce greenhouse gas emissions. This project will help research and identify existing methods to build a model to assist ATA in evaluating the performance levels of the measures for a business-as-usual scenario. These assessments will help evaluate emissions under varying scenarios to identify which action or policy applications have a better outcome and will assist in reducing CO_2 emissions at different levels within the state. This improvement will help ATA capture precise changes in transport activities and understand how different areas will contribute to emissions at regional levels.

The work focuses on all Australian states and territories with the following breakdown: Capital Cities, Other Urban Areas, Other Areas, Total Interstate. Considering time constraints, aims and focus of the project only Light Commercial Vehicles, Rigid Trucks and Articulated Truck Types are selected for modelling.

2. Data and Methodology

This section outlines the methodology and data sources used to estimate the total emissions in the freight transport industry. The methodology involves activity projection and emission intensity projection. Activity projection highlights the demand for freight tasks, which depend on economic factors, including per capita income levels, population growth, road freight cost and average load carried. Additionally, a fundamental estimate is built to project the emission intensity. By understanding the relationship between these components, policymakers can explore the potential measures and, ultimately, the existing policies to reduce emissions in road transport. The relationship between the projection variables is illustrated in Figure 2. In the following sections, a detailed analysis of each variable is provided. The discussion covers the data sources used for variable collection, challenges in data processing, including missing values or unavailable data, and the methods for building total emissions projection.

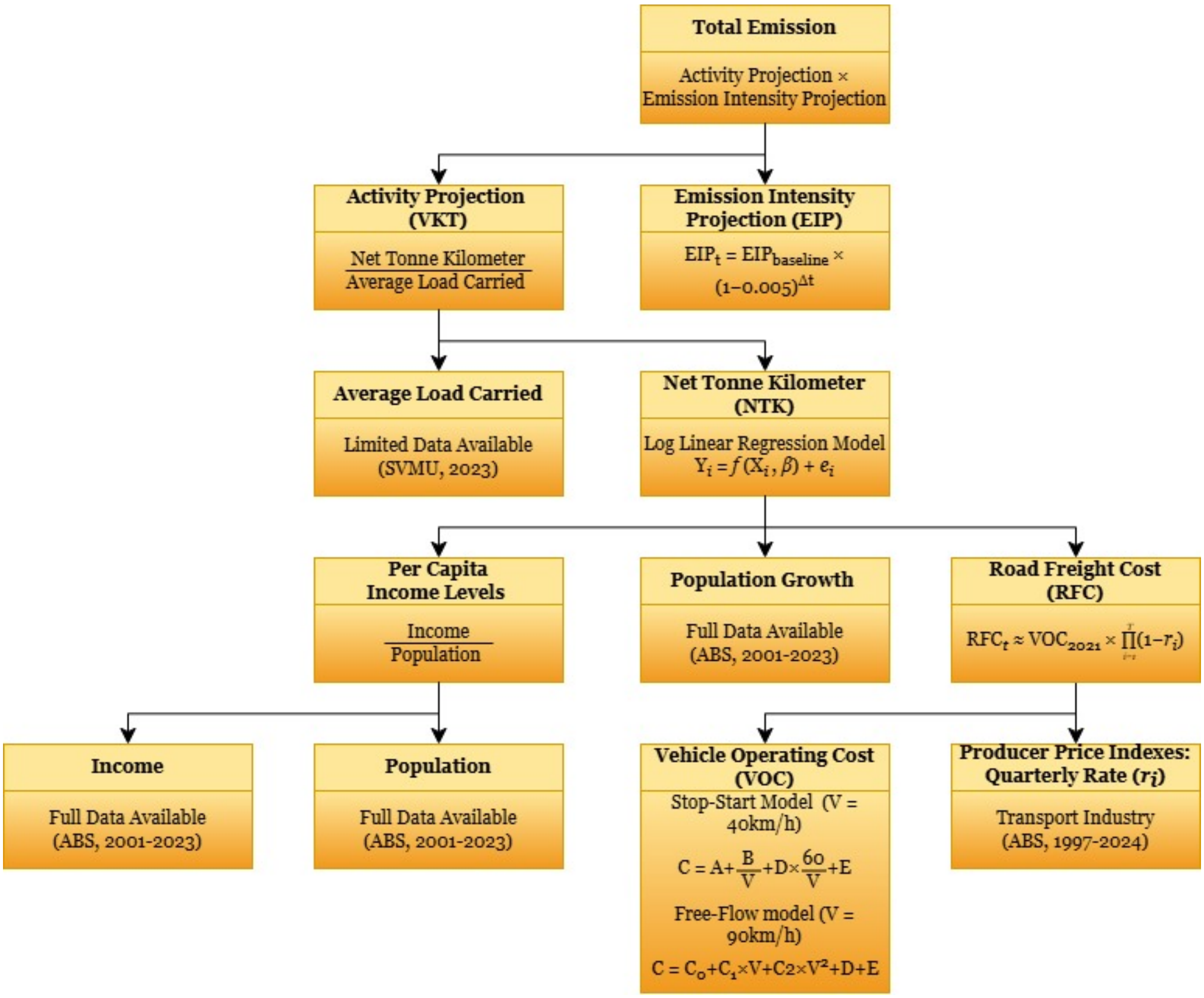

Figure 2. Flowchart of methodology for total emission in freight transport

2.1.1 Activity Projection

Freight activity forecasts were based on the analysis by the Bureau of Infrastructure and Transport Research Economics (BITRE) (2022) [17]. The road freight activity of BITRE is modelled as a single-equation econometric model related to road freight task, which depends on domestic economic activity and road freight cost [11]. By further studies a road freight forecasting model was assembled to represent freight activity affected by future population growth, per capita income levels and freight costs [18]. A log-linear regression was selected to model the total emissions estimates due to its ability to capture exponential growth. The approach accounts for different vehicle types across urban regions for all states. For each unit increase in the independent variable, Net Tonne-Kilometres (NTK) increases by a factor that is displayed in the log-linear Equation 2:

$$Log(NTK) \sim Population\ Growth + Per\ Capita\ Income\ Levels + Road\ Freight\ Cost$$

Following that, the value of Activity Projection(Vehicle Kilometers Traveled) is calculated by dividing the NTK by the Average Load carried, as expressed in Equation 3:

$$Activity\ Projection\ = \frac{NTK}{Average\ Load\ Carried}$$

2.1.2 Emission Intensity Projection

The emissions intensity of each segment is assumed to improve by 0.5% per year [17], applying the Equation 4:

$$Projected\ Emission\ Intensity\ (Year) = Baseline\ Emission\ Intensity\ x\ (1-0.005)^{Years}$$

2.2 Data Preparation and Processing

All data used are obtained from various sources of Australian Bureau Statistics (ABS) to ensure data reliability and future reusability; data sources are elaborated upon in the following sections. The time frame of the analysis was years 2001 to 2020, using the following key datasets:

- Net Tonne-Kilometre (NTK): Survey of Motor Vehicle Use, ABS
- Average Load Carried: Survey of Motor Vehicle Use, ABS
- Total Population: Estimated Resident Population, ABS
- Total Income: Estimates of Personal Income for Small Areas, ABS
- Deflation Rate for Road Freight Cost: Producer Price Indexes, Australia, ABS

2.2.1. Net Tonne-Kilometre

Net tonne-kilometres are taken from the Survey of Motor Vehicle Use of the Australian Bureau of Statistics. The unit of measurement for NTK is million tonne-kilometres. The survey was not conducted consecutively, and the approach was adjusted over time. Therefore, there are some missing data and data are not separated into the desired categories. From 2010 to 2020, the survey was conducted every two years, which resulted in missing data in odd years. From 2001 to 2009, the survey was conducted every year, but data from the years 2008 and 2009 were missing. An example of missing value throughout the year across all regions from New South Wales (NSW) with Rigid Truck is shown in Figure 3.

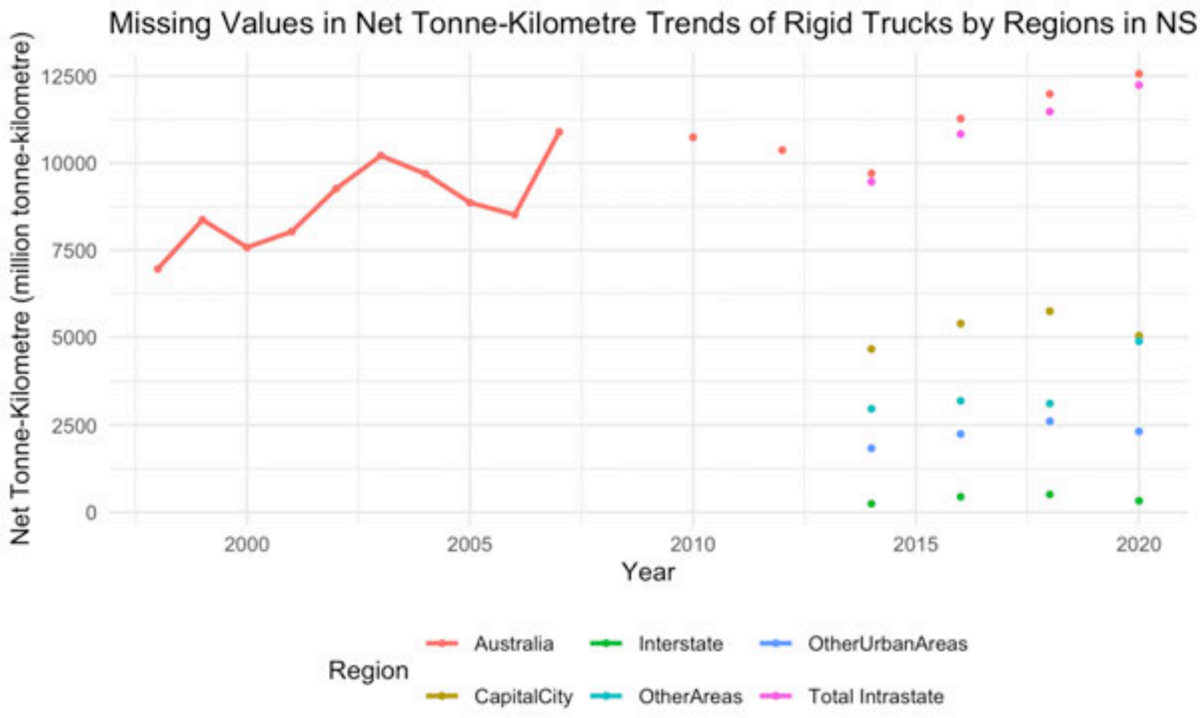

Figure 3. Missing values in net tonne-kilometre trends of rigid trucks by region in NSW

The values for the years 2012-2020 for all vehicle type across every region is filled using interpolation. Following that, interpolation is also applied to the total tonne-kilometre of three types of vehicles in the states for 2001-2011 to estimate the missing data. Based on data obtained from 2012-2020, the average rate per vehicle across all regions was calculated to then be multiplied by the total ton-kilometer in 2001-2011.The resulting values are an estimated NTK for each region and vehicle type during the missing years. Continuing with the example in Figure 3, after filling in the missing values, Figure 4 presents an example of NTK's completed dataset of Rigid Truck across all NSW regions.

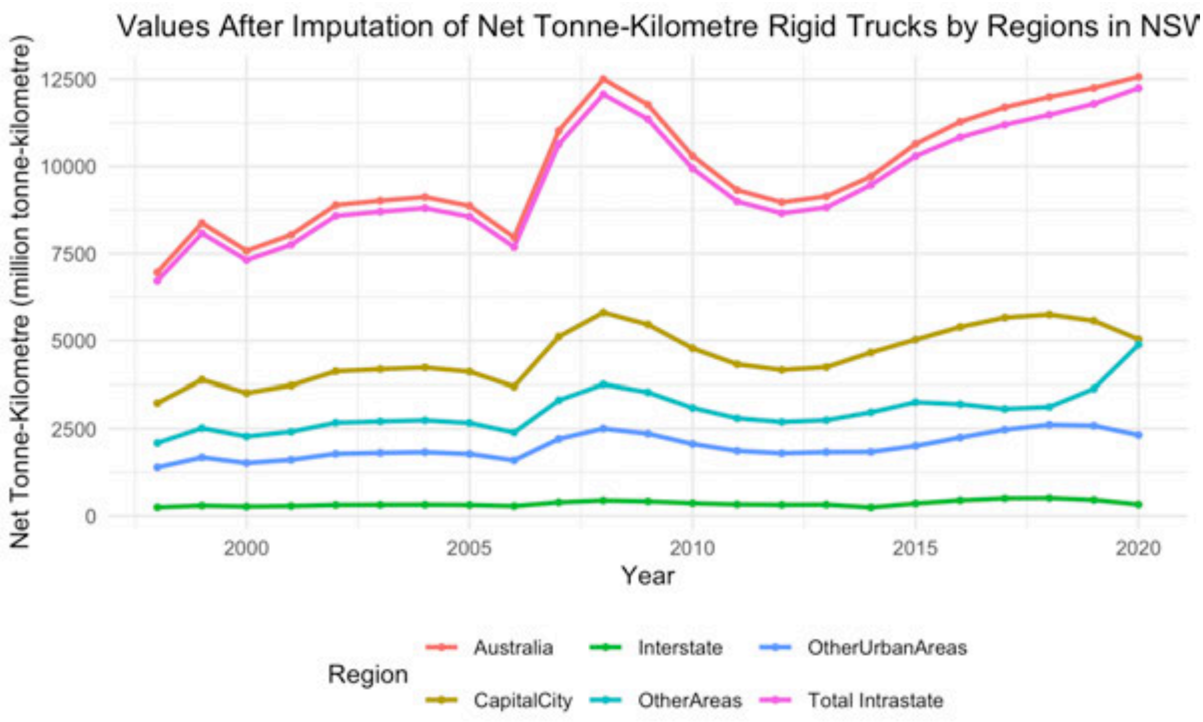

Figure 4. Net tonne-kilometre rigid truck by regions in NSW after imputation

2.2.2 Population Growth

Population data are taken from ABS and filtered based on Table 1 (Appendix) to analyse data on required areas. The unit of measurement for Population Growth is person. The urban area is divided based on the Australian Standard Geographical Classification (ASGC) 1996. Urban areas are defined as areas or clusters of collection districts and other urban areas with a population greater than 40,000 based on the 1996 Population Census [19]. After that, the population in other areas is calculated by taking that state's total minus the capital city and other urban areas. The data are available from 2001 to 2020 [19].

Since Population Growth is not available in the required regions, after collecting the total population of the regions across the states, nominal population growth is calculated using the Equation 5:

$$\begin{aligned} &Population\ Growth\ in\ Year\ t \\ &\qquad = Total\ Population\ in\ Year\ t - Total\ Population\ in\ Year\ (t-1) \end{aligned}$$

An example of the population growth of New South Wales breakdown by region is shown in Figure 5.

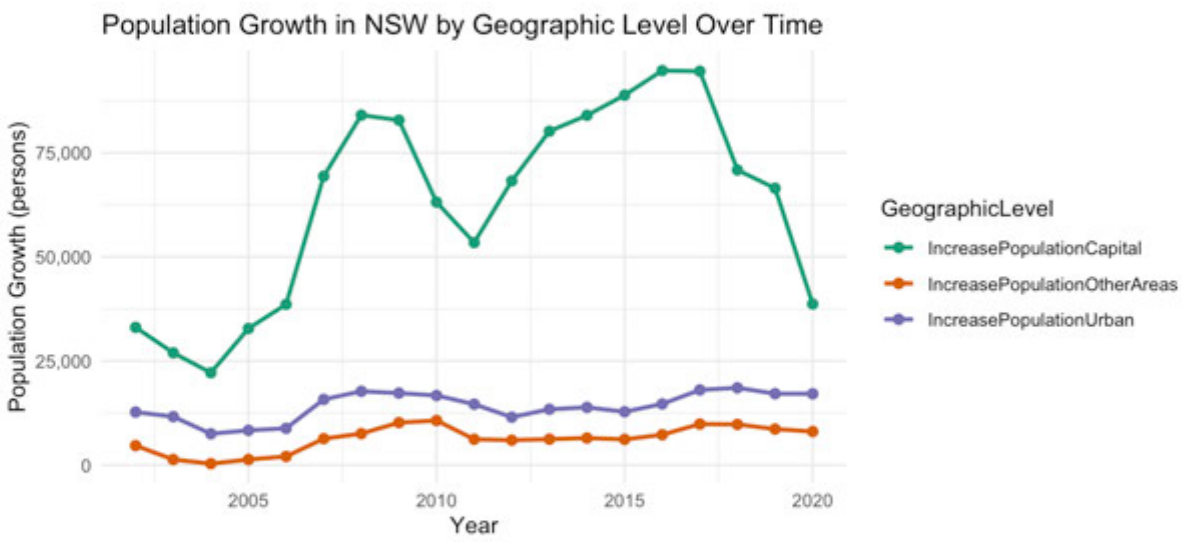

Figure 5. Population Growth in NSW by Geographic Level Over Time

2.2.3. Per capita Income Levels

Per capita income levels is the average income per person in specific areas within the states. The unit of measurement for Per capita Income Levels is AUD/person. Data on per capita income level are not available from government data sources. Therefore, this variable is etatized by the sources available from the government using the Equation 6:

$$Per\ Capita\ Income\ Levels = \frac{Total\ Income}{Total\ Population}$$

To collect income data for regions, these data are filtered by regions in Table 1 (Appendix). An example of the per capita income levels breakdown by region is shown in Figure 6.

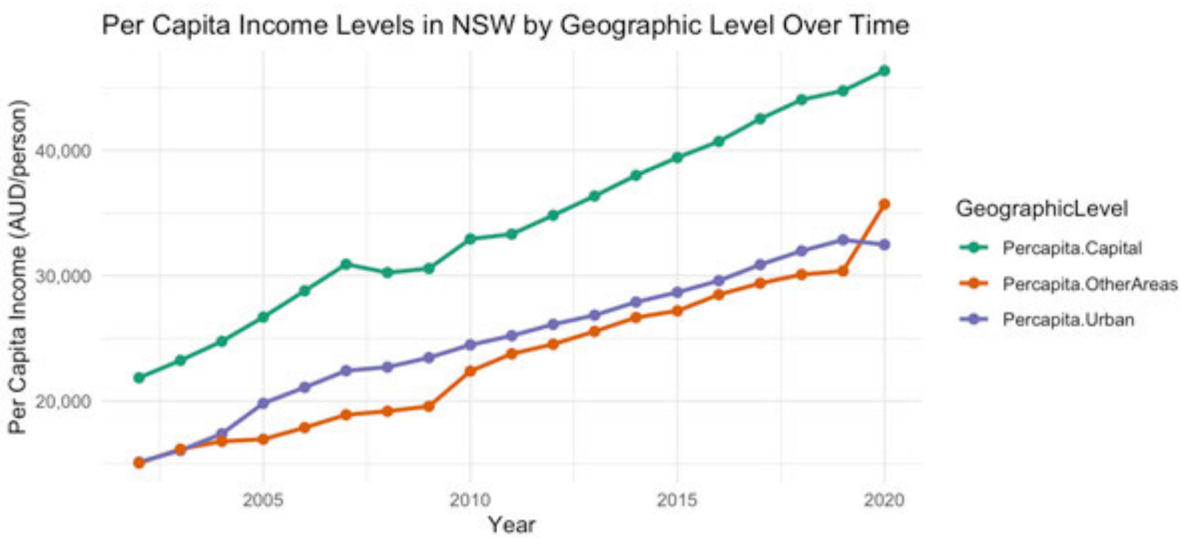

Figure 6. Per capita income levels in NSW by pegions over time

2.2.4. Road Freight Cost

Road Freight Cost uses the Vehicle Operating Cost (VOC) formula from TfNSW Economic Advisory [20]. The unit of measurement for road freight cost is cents/km. With the start - stop formula applied to calculate the cost for the urban area, as shown in Equation 7:

$$c = A + \frac{B}{V} + D \times \frac{60}{V} + E \ [20]$$

The freeway formula is used to calculate the cost for the rural area, as shown in Equation 8:

$$c = C_0 + C_1 \times V + C_2 \times V^2 + D + E[20]$$

In these two formulas, c represents VOC and A, B, C1, C2, C3, D and E are model coefficients, which are given in the Table 2 (Appendix). The speed of densely populated urban areas is assumed to be 40km/h, while the speed for rural areas is allowed to run at a high speed of 90km/h. Since VOC is applied to each specific vehicle, all vehicles are calculated and then the values of these values are averaged for the vehicles. The values calculated by this formula correspond to VOC 2021 because the coefficients are estimated according to 2021 prices. To estimate the value in 2001-2020, the deflation rate was calculated from Producer Price Indexes under Transport, which reflect the price change in the transport industry, as shown in Equation 9:

$$Deflation\ Rate\ (\%) = \frac{(Index\ value\ (Year\ 2) - Index\ value\ (Year\ 1)}{In\ dex\ value\ (Year\ 1)}$$

The deflation rate is then multiplied by the 2021 VOC value to calculate the value of road freight costs from 2001 to 2021. An example of the breakdown of road freight costs by freight vehicle type and area is shown in Figure 7.

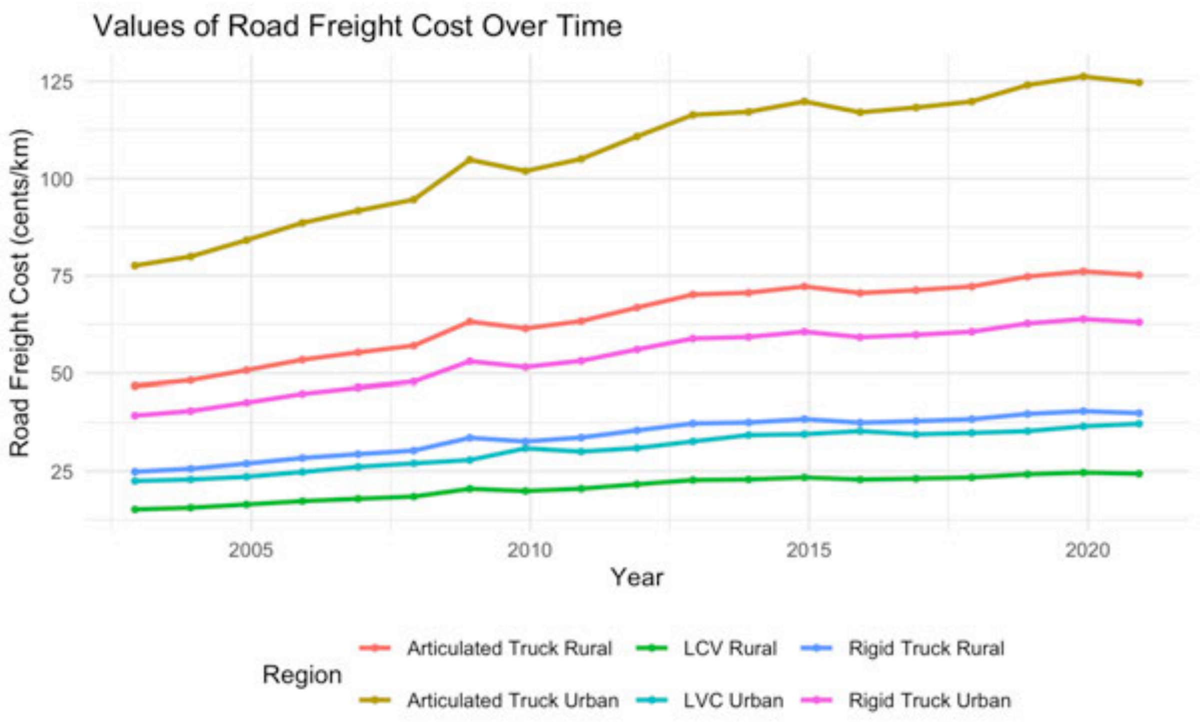

Figure 7. Road freight cost of freight vehicles in urban and rural areas over time

2.2.5 Average Load Carried

Average Load Carried is taken from the Survey of Motor Vehicle Use. The unit of measurement for Average Load Carried is tonne. However, this value is only available for each freight vehicle's total average load carried by the state. To address this problem, the approach uses the relevant values broken down into required regions to calculate the value of the Average Load Carried, calculated by the Equation 10:

$$Average\ Load\ Carried = \frac{Average\ Tonne - Kilometres}{Average\ Kilometre\ Travelled}$$

An example of average load carried by rigid truck in NSW by regions over time after calculation as illustrated in Figure 8.

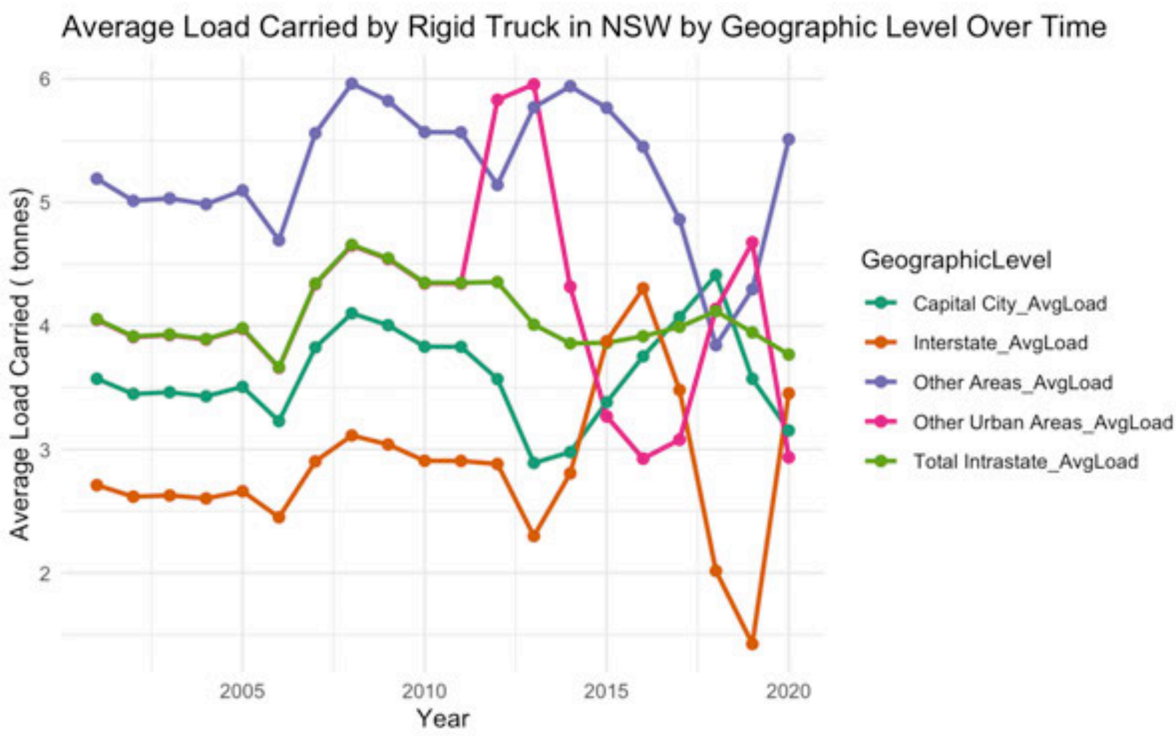

Figure 8. Average load carried by rigid truck in NSW by regions over time

3. Results and Analysis

This section will focus on analysing the NTK results because the projection of this variable requires a regression model. In contrast, the calculations of other variables, such as the average load carried or the emission intensity, follow a straightforward calculation project using formulas.

3.1 Fitness

An adjusted R-square is used to evaluate the performance of the model. It measures the amount of variation in the response variable that can be explained by our predicting variables. The higher the adjusted R-squared value, the better the model performs. As shown in Figure 9, most models with high adjusted R-Square are articulated trucks and rigid trucks. This shows that the model performance for articulated trucks and rigid trucks is better than for light commercial vehicles. In addition, it shows that the models work better in Western Australia, Victoria, South Australia, and Queensland than in other states.

Different economic drivers influence freight activity in each state since the relationship between variables and designers varies across states. Understanding the relationship will benefit the organization when adjusting policies to fit states. Another performance metric used is p-value. When p-value is < 0.05, it indicates that independent variables significantly influence response variables. Per Capita Income Level has a stronger influence in Victoria and South Australia, while Road Freight Cost plays a bigger role in Queensland and Western Australia. In New South Wales, Northern Territory and Tasmania, Population Growth is the most significant factor, as shown in Figure 10.

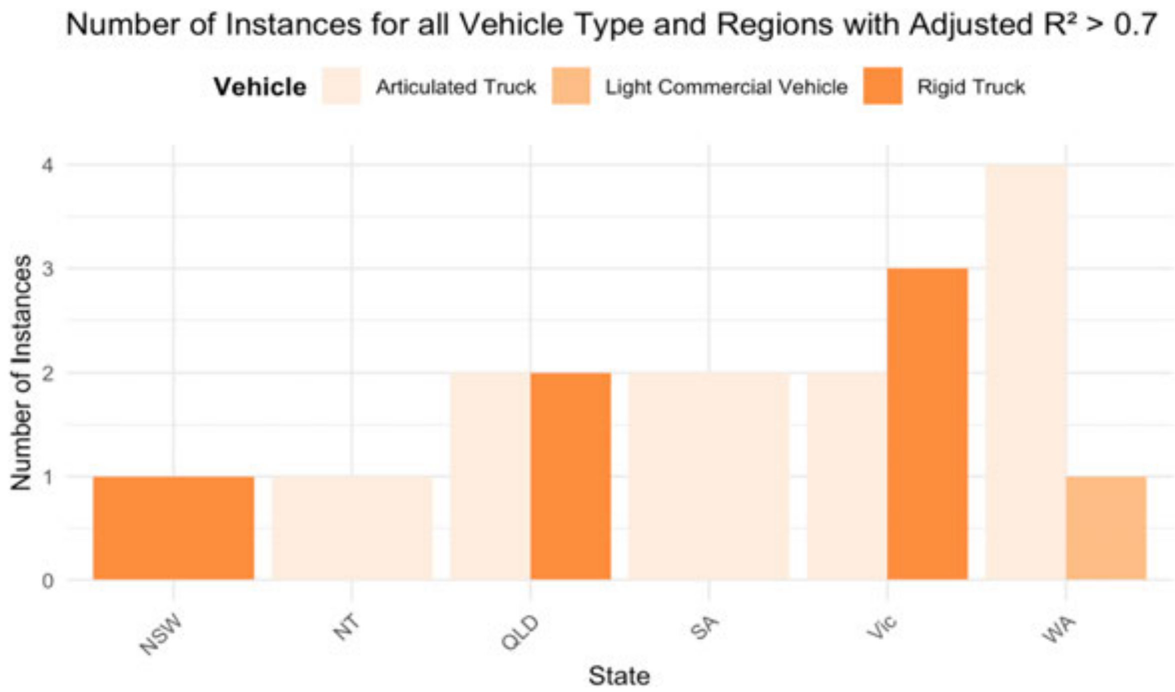

Figure 9. Number of models with high adjusted R^2 (>0.7) across vehicle types and states

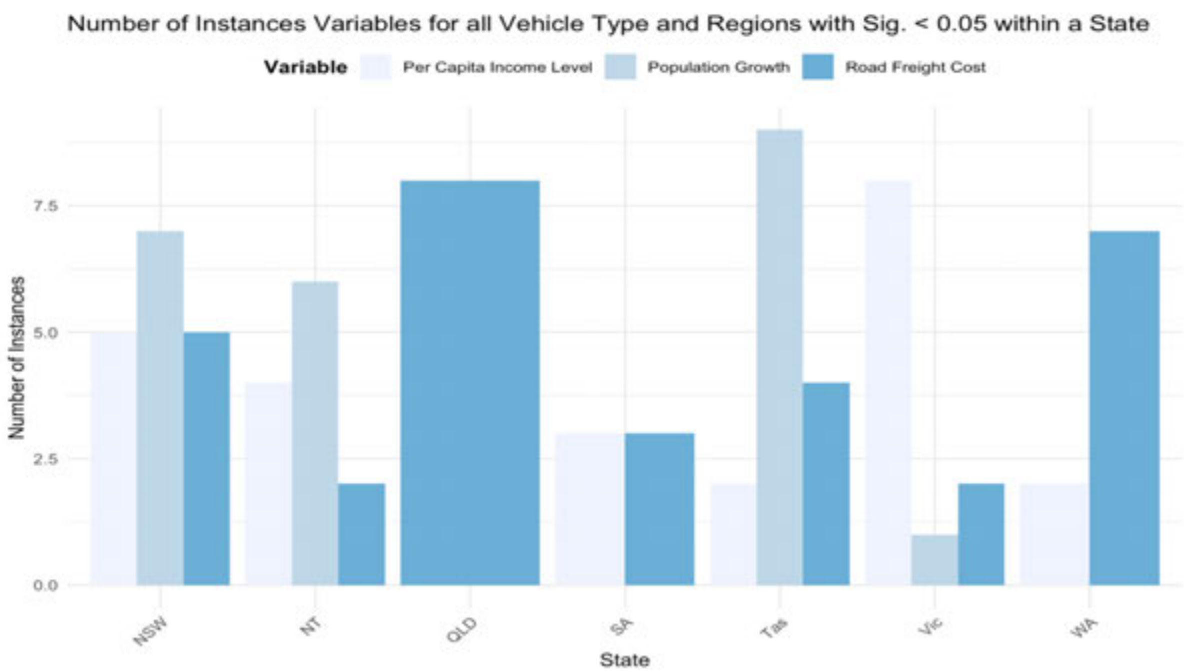

Figure 10. Distribution of statistically significant variables (p < 0.05) by state

3.1.2. Difference between models including and excluding the Road Freight Cost

The importance of Road Freight Cost is questioned as to whether it affects the freight task. Therefore, two models are compared to find the results using ANOVA function. The performance metrics used are p-value and F-value. When the p-value is < 0.05, this explains that Road Freight cost significantly impacts the improvement of freight tasks. The F-value shows whether the additional variable has improved the model fit. Therefore, the higher the F-value, the better the model fit when Road Freight Cost is included.

Overall, the performance of the freight task model with road freight cost and without road freight cost shows comparable performance. However, the freight task model with road freight cost shows a statistically significant improvement in some areas.

The most significant improvement when adding road freight cost is the articulated trucks in Western Australia and Queensland rural areas, where F-values are greater than 80 and 38, respectively. This indicates that Road Freight Cost has a large influence on the development of freight tasks in this area. In contrast, Tasmania and South Australia, New South Wales, Northern Territory and Victoria have small F-values, ranging from 4.6 to 11.2, as shown in Figure 11. This shows that road freight cost has a moderate influence on these areas.

No.	State	VehicleType	Area	F_value	p_value	Significant
	<chr>	<chr>	<chr>	<dbl>	<dbl>	<lgl>
5	SA	Rigid	CapitalCity	11.194211	4.42E-03	TRUE
7	SA	Rigid	Australia	7.016137	1.82E-02	TRUE
8	SA	Rigid	TotalInstrastate	4.657636	4.75E-02	TRUE
9	SA	Arti	CapitalCity	4.859211	4.35E-02	TRUE
22	NT	Arti	OtherAreas	6.055781	2.65E-02	TRUE
1	NSW	LCV	CapitalCity	4.752478	4.56E-02	TRUE
4	NSW	LCV	Australia	5.717618	3.03E-02	TRUE
51	NSW	LCV	TotalInstrastate	5.436275	3.41E-02	TRUE
10	NSW	Rigid	TotalInstrastate	6.093302	2.61E-02	TRUE
12	NSW	Arti	Urban	6.678843	2.07E-02	TRUE
24	VIC	Rigid	Australia	5.193489	3.77E-02	TRUE
28	VIC	Arti	OtherAreas	6.477102	2.24E-02	TRUE
32	QLD	LCV	Urban	10.032316	6.38E-03	TRUE
33	QLD	LCV	OtherAreas	5.516802	3.30E-02	TRUE
37	QLD	Rigid	Urban	14.940354	1.53E-03	TRUE
38	QLD	Rigid	OtherAreas	8.24494	1.17E-02	TRUE
42	QLD	Arti	Urban	25.540168	1.43E-04	TRUE
43	QLD	Arti	OtherAreas	38.905971	1.59E-05	TRUE
44	QLD	Arti	Australia	26.839312	1.12E-04	TRUE
45	QLD	Arti	TotalInstrastate	37.902402	1.84E-05	TRUE
48	WA	LCV	OtherAreas	10.22942	5.98E-03	TRUE
53	WA	Rigid	OtherAreas	22.170827	2.80E-04	TRUE
55	WA	Rigid	TotalInstrastate	5.130874	3.87E-02	TRUE
56	WA	Arti	CapitalCity	9.729255	7.04E-03	TRUE
58	WA	Arti	OtherAreas	83.164473	1.66E-07	TRUE
59	WA	Arti	Australia	13.416319	2.31E-03	TRUE
60	WA	Arti	TotalInstrastate	10.899147	4.85E-03	TRUE
69	Tas	Rigid	Australia	4.920683	4.24E-02	TRUE
73	Tas	Arti	OtherAreas	5.507787	3.31E-02	TRUE

Figure 11. ANOVA Results: Significant factors by state, vehicle type, and area

3.2. Model Outcome

The project presents a data-driven approach using regression models to project freight transport emissions under a business-as-usual scenario. This approach is intended to assist policymakers in assessing the effectiveness of existing measurements based on key metrics, including population growth, economic changes, freight rates, average load carried and emissions intensity. Policymakers can utilize the model by selecting the desired model attributes and corresponding weights, available in the Excel file provided in the Final Submission folder. Attribute selection options include:

- State: Choose from six states and two territories.
- Region Type: Select from five categories:
  - Capital City
  - Other Urban Areas
  - Other Areas
  - Total Intrastate

    - Australia
- Vehicle Type: Choose from three categories:
    - Light Commercial Vehicles
    - Rigid Trucks
    - Articulated Trucks

The right part of the equation combines model weights and three input variables. An example of project NTK in New South Wales with Rigid Truck in Other Areas is illustrated as Equation 10:

$$\begin{aligned} Log(NTK) = 8.11E &+ (2.84E-5) \times PopulationGrowth \\ &+ (2.97E-5) \times Per\ Capita\ Income\ Levels \\ &+ (-2.79E-2) \times Road\ Freight\ Cost \end{aligned}$$

To calculate total emissions in 2030, users must collect input data on vehicle types and specific regions within the state for which they want to make projections, including Population Growth, Per Capita Income Level, and Estimated Road Transport Cost of the target year. Next, these values will be inserted in their placeholders to obtain the estimate the NTK value in 2030. The projected NTK value will be divided with the average load carried value in 2030 to project the activity for that year. Subsequently, the activity project value will be multiplied by the emission intensity projection of the target year to calculate the final value of total emission.

4. Conclusion and Recommendation

4.1 Conclusion

While Australia has taken action to reduce greenhouse gas emissions, it remains a significant issue, with a growth of 0.8% between 2022 and 2023 [5]. The freight industry understands implicitly that it needs to implement revolutionary changes and highly efficient policies to achieve the net zero emissions target by 2050.

In acknowledging this need, this report has provided policymakers with a new, detailed view of freight demands at various levels of regions across Australia. The effective total emissions formula includes important causes of emissions increases during freight transport. A freight activity projection model is built based on a business-as-usual scenario with a target on freight vehicles, including light commercial vehicles, rigid trucks and articulated trucks. Additionally, the fundamental formula for calculating the emission intensity is also provided.

One of the model's important findings is to find out the different levels of influence of economic factors in the states, helping policymakers make better adaptation decisions for each region to achieve high efficiency. Another crucial finding is that the model used to project Net Tonne-Kilometre works better for Rigid Truck and Articulated Truck in South Australia, Victoria, Queensland and Western Australia.

4.2 Potential Model Enhancements

The original model was built to project emissions in transport at the state level only. However, the current model used in this study constructed freight tasks across regions, states, and vehicle types. Therefore, the current variables might not provide a complete understanding of the freight activity of the regions. Several areas can be improved to increase the accuracy for all regions and vehicle types.

First, adding more factors and observations are recommended for models with low adjusted R-square to better explain freight tasks in these regions. The added variables will help to explain more with the evolution of freight tasks in the regions. Additionally, due to the limitations of existing current data, the analysis of the project is only from 2001-2020 with an acknowledged amount of missing data, the model might not capture all the trends. It would be better to have more historic data to capture the complex representation that the current model might missing.

Next, the suggested Road Freight Cost calculation method should try the value provided by the Operator Cost Model from the National Transport Commission for Rigid and Articulated Trucks in 2020 and then also apply the deflation rate from the Produce Price Indexes to calculate the road freight cost value for previous years. Performing this calculation method helps to compare the performance between the two to see whether the model with the new Road Freight Cost value performs better than the Road Freight Cost value currently in use.

Currently, the emission intensity projection method is based on only 0.5% annual growth based on baseline emission intensity. This calculation also does not clearly show the influence of factors on emission intensity. Therefore, this project recommends building a detailed model that shows the influence of fuel factors on emission intensity. This method helps to understand the importance of different factors affecting emission intensity and provides a more comprehensive view of emission.

Another recommendation for developing a better model is to use different techniques to find missing values. The Average Load Carrying and NTK datasets have more than 50% missing data for regions. Therefore, trying different methods will help to check which dataset values provide a more accurate model. The suggested method is machine learning techniques, including K-Nearest Neighbors Imputation or Time Series Forecasting.

On the other hand, regarding the economic components that affect the freight transport task, BITRE mentioned using either per capita income or per capita GDP. In this project, per capita income was used, so in the future, per capita GDP is proposed to evaluate the impact on the model.

In 2017, approximately 32% of Australia's total tonne-kilometres were for interstate freight movements [21]. Therefore, when one state's economy in Australia is affected, it will also affect the freight tasks of other states. Therefore, state-to-state freight task projection is recommended. Applying this approach can fill the gap of missing data, capture state-specific trends, and increase the model's reliability.

5. Closure Activities

5.1 Project Documentation

The output of this project includes eight datasets, five programming files, one coefficient models in Excel, one presentation slide and one report. These components are saved in Final Emission at channel WRF3- BAU Model Road Freight Transport Emission.

6. References

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Appendix

A.1 Methodology for Total Emission in Transport Industry

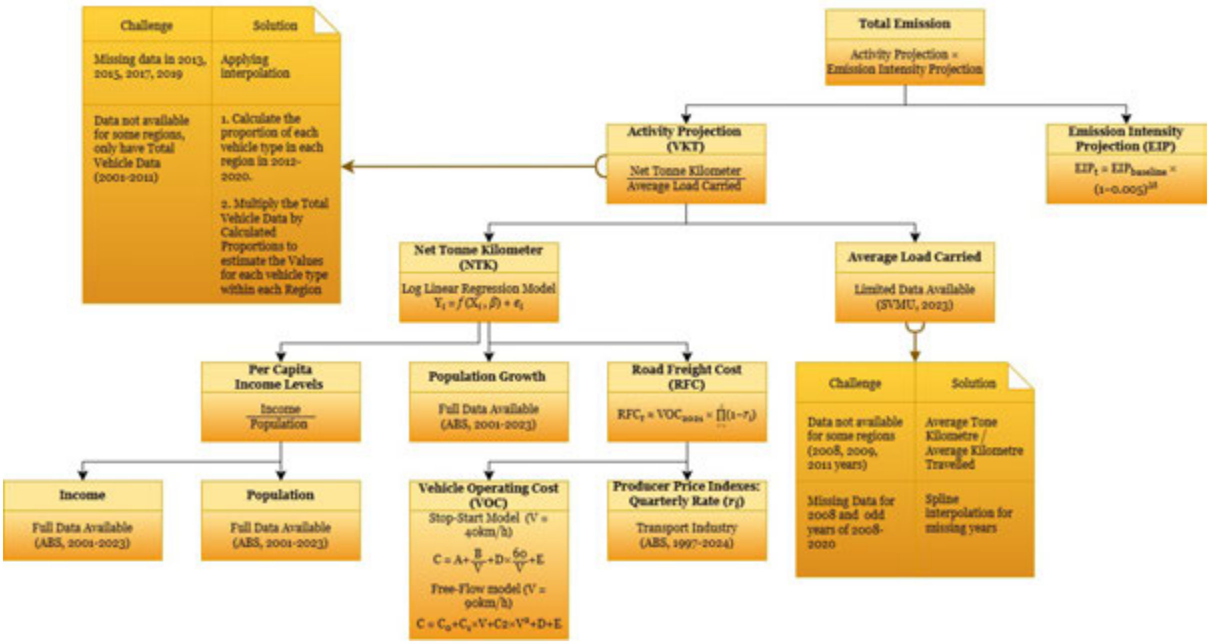

Figure 1. Flowchart of Methodology for Total Emission in Freight Transport

A.2. The division of regional areas within Australia

State/Territory	Capital City	Other Urban Areas	Other Areas
New South Wales	Sydney	Newcastle, Lake Macquarie, Port Stephens, Wollongong, Kiama, Bathurst-Orange, Maitland, Albury (excluding Wodonga), Hume, Wagga Wagga, Tweed Heads (excluding Gold Coast), Queanbeyan (excluding Canberra ACT), Coffs Harbour, Tamworth, Shellharbour, Cessnock, Nelson Bay.	Remaining Areas
Victoria	Melbourne	Geelong, Ballarat, Bendigo, Wodonga (excluding Albury), Shepparton, La Trobe Valley and Mildura.	Remaining Areas

Queensland	Brisbane	The Sunshine Coast, Bundaberg, Hervey Bay, Rockhampton, Mackay, Townsville, Cairns, Gold Coast (excluding Tweed Heads), and Toowoomba.	Remaining Areas
Western Australia	Perth	Mandurah, Bunbury and Rockingham.	Remaining Areas
Tasmania	Hobart	Launceston, Burnie, Devonport, Wynyard and Latrobe.	Remaining Areas
South Australia	Adelaide	N/A	Remaining Areas
Northern Territory	Darwin	N/A	Remaining Areas
Australian Capital Territory	Canberra	N/A	Remaining Areas

Table 1. Australian Standard Geographical Classification (ASGC) 1996

A.3. Road Freight Cost

Vehicle Type	Stop-start model		Free flow model			Depreciation	
	A	B	C_0	C_1	C_2	D	E
Cars							
Small Car	14.2405	953.1777	29.3302	-0.1425	0.0011	-8.0155	1.8513
Medium Car	14.3852	1495.7973	39.8499	-0.1991	0.0014	-16.7527	4.0117
Large Car	16.4072	2090.4214	52.5046	-0.2525	0.0016	-23.9710	5.7403
Utility vehicles							
Courier Van-Utility	18.7113	1593.5314	45.1973	-0.2160	0.0016	-10.7722	1.3454
4WD Mid-Size Petrol	24.7146	1560.2677	47.6231	-0.1809	0.0015	-17.7113	2.0216
Rigid trucks							
Light Rigid	38.6249	1755.0844	58.5681	-0.2821	0.0028	-13.4435	1.5647
Medium Rigid	40.7104	2569.6038	71.2689	-0.3413	0.0030	-28.0377	3.4434
Heavy Rigid	64.9932	2906.3635	93.5671	-0.6282	0.0060	-33.2530	3.8753
Heavy Bus	75.8026	5439.0653	146.4242	-0.7593	0.0055	-48.8335	5.6454
Articulated trucks							
Articulated 4 Axle	96.1608	3778.3979	126.9644	-0.8232	0.0082	-40.6913	4.6211
Articulated 5 Axle	103.6189	4194.0992	136.3305	-0.7732	0.0075	-44.8731	5.0959
Articulated 6 Axle	112.2149	4538.2438	146.3234	-0.7821	0.0075	-48.6483	5.5247
Combination vehicles							
Rigid + 5 Axle Dog	139.3456	4240.9865	154.8217	-0.7280	0.0074	-42.4747	4.8236
B-Double	139.8469	5221.4997	172.2294	-0.8219	0.0077	-55.5378	6.3071
Twin steer + 5 Axle	144.6285	4980.2060	170.4777	-0.7858	0.0076	-51.7566	5.8776
A-Double	163.7259	6472.0398	208.6872	-0.9472	0.0084	-70.1173	7.9628
B-Triple	169.8896	8112.1684	243.4892	-1.1232	0.0092	-91.2122	10.3584
A B combination	193.6623	7115.4272	237.3089	-1.0253	0.0091	-76.4162	8.6780
A-Triple	216.7748	8112.7034	269.5562	-1.1519	0.0098	-87.8775	9.9797
Double B-Double	226.9197	7932.3540	271.4398	-1.1236	0.0098	-55.5378	6.3071

Source: TfNSW Economic Advisory (2022) based on ATAP (2016). Coefficients produce VOC estimates in December 2021 prices

Table 2. VOC model coefficients for stop-start and free-flow models (cents per km), $2021