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Modeling rural freight

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Abstract

This paper illustrates the modeling of passengers and freight in a rural multimodal network for a proposed railway with emphasis on road/rail competition for export freight. This modeling is much more complex than modeling urban traffic as the forecasting assumptions necessary to build the model are much more diverse and questionable and consequently need to be supported by external evidence. Australia's rural export economy is vitally important to our economic wellbeing and modeling freight movements to export ports is an essential ingredient in supporting these industries.

1. Introduction

This paper provides a case study of the modeling of a New South Wales rural multimodal network to assess passenger and freight movements for a proposed Canberra to Eden railway with improvements to Eden Port. The proposed project consists of upgrading the existing abandoned rail route between Queanbeyan and Bombala and the provision of a new rail alignment between Bombala and Eden. The preferred route was identified as the Towamba Valley route and the engineering and cost estimates for this proposed route was adopted[1] for the passenger and freight modeling and subsequent economic evaluation.

The passenger and freight demand forecasts have been assessed with the assistance of the upgraded CARTS model[2], which is a State-wide multi-modal transport forecasting model which incorporates estimates of road/rail competition, rail route diversion and rural industry growth induced by improved freight transport facilities. It also incorporates facilities for economic evaluation. The model utilized a network inventory of all road and rail routes in NSW.

While the proposed rail improvements will connect into the National Rail network and is therefore able to accept passengers and freight loads from any part of Australia, the most probable freight loads are likely to be from a catchment area, which stretches from Dubbo and Carathool Shire to Bega Valley Shire and Goulburn. It is therefore necessary that the model should embrace at least the whole area of the State of New South Wales.

The evaluation relies on an assumption that the port development, together with the social infrastructure within the town of Eden, will grow to support this development. Some part of the passenger and freight traffic supporting this future development will be induced by the rail development – other development will occur as natural growth.

[1] Cooma and Monaro Progress Association. "Concept Plan for Canberra to Eden Railway". Stormcloud Engineering, 2018
[2] Scott Wilson Nairn, "Program CARTS Description and user manual".

Similarly socio-economic growth will occur at intermediate towns along the proposed rail routes and they also will contain induced elements. It is assumed that both the port and townships development will keep pace with the expected demand for socio-economic services so that rail commerce will not be constrained by social or terminal capacity limitations in future.

The natural growth of towns and the port does not form a part of the economic assets of the rail proposal although the value of a part of any new rural growth and industrial production, induced by improved rail services, was included within the benefit stream. The proposed railway is shown in Figure 1 and the existing rail network within the potential catchment area is shown in Figure 2.

Figure 1 – The proposed railway

Source: "Concept Plan for Canberra to Eden Railway" prepared by Edwin Michell of Stormcloud Engineering

Figure 2 The existing New South Wales rail network in the probable catchment area

Cootamundra is the focal point for rail transit in the Riverina. It is about 60 Km closer to Port Botany than Port Eden and Port Kembla with Port Melbourne being not much further.

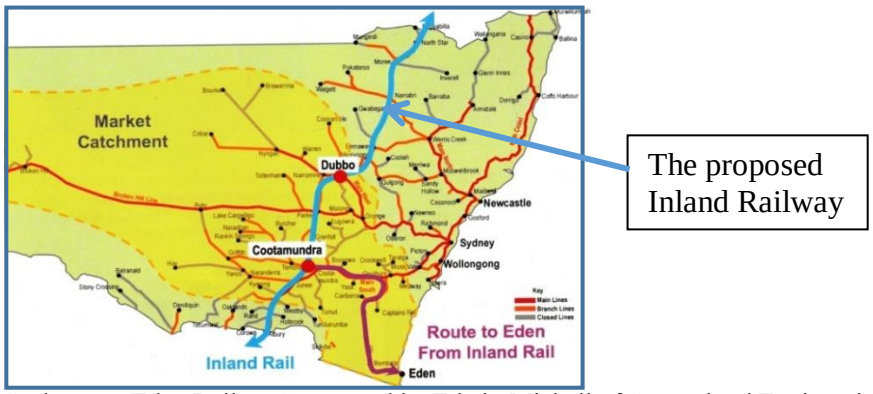
2. Methodology Overview

The CARTS model utilizes socioeconomic data from each of the Local Government Areas in the State to simulate the passenger and freight loadings on the network and is calibrated so that these loadings reflect the actual loadings on the real network in the "base" year, in this case 2021. The calibration acknowledges any network congestion and serious bottlenecks causing delays. However few details of rail traffic were available.

The first simulation test was just for the necessary improvements to the port at Eden, which was to include both bulk and new container handling facilities, but without the rail improvements. This established the degree to which the port improvements will continue to attract freight by road. While the ensuing economic benefits from this test are not attributable to the rail project, it provides a basis for examining the degree to which the rail project, when tested, will induce freight transfers from road transport. This showed that about half of cost of the port improvements could be attributed to road improvements.

The future traffic forecasts depend on forecasts for the socioeconomic parameters of each Local Government District. They include population, employment, vehicle ownership, rural industry and agricultural production, mining, manufacturing and tourism. These forecasts are assembled for several future years. Applying these within the CARTS simulation model, together with the upgraded networks, in each future year, provides the demand forecasts. The forecasts also depend on future changes to the transport network. Although some rail changes may be expected in the Riverina, the only significant new rail line is the Inland Rail shown in Figure 3.

Figure 3 - Future changes to the rail network



Source: "Concept Plan for Canberra to Eden Railway" prepared by Edwin Michell of Stormcloud Engineering

The modeling provides predictions of induced growth in rural production and tourism as a result of the improved transport access. There may also be some shifts in residential population. Preparation of the data involved resolving the following questions:-

- What are the Local Government growth rates – ex-urban migration patterns etc?
- What is the potential growth in tourism in the catchment area?
- What is the potential growth for rural export produce and what factors affect it?
- What is the potential export market and it's growth for NSW rural produce?
- What are the competing ports and their conditions – container and bulk handling facilities?
- What is the cross-elasticity between road and rail and rail routes haulage? and
- Are there capacity limits in the network?

3. The relevant potential market for passengers and freight

In view of the importance of freight haulage to the rail proposal, the potential market for exports and imports from the catchment area is a primary focus. The primary export products from the catchment area are agricultural products. The top three agricultural commodities produced nationally ranked by export value in 2018-19 were cattle and calves ($9.485 billion), wool ($4.159 billion) and wheat ($3.676 billion). Out of the $62.2 billion worth of food and fibre Australian farmers produced in 2018-19, 79% ($49.2 billion) was exported. The pre-COVID value of export sales of commodities produced in the catchment area to countries easily served from the eastern seaboard in the year 2019 in shown in Table 1. Table 2 illustrates the value of the major imports from some of the above countries.

Table 1 - Value of commodity exports to eastern seaboard countries $Millions - 2019

Commodity	China	Vietnam	Japan	Korea	Malaysia	NZ	USA	HK	S'pore	Total
Foodgrains	693	373	552	38	225	56	0	0	33	2,470
Meat/Cattle*	3,974	629	2,836	1,759	319	148	3,353	300	270	13,588
Dairy Products	643	61	514	74	149	87	38	101	173	1,840
Cotton	1,116	114	23	1	44	2	0	0	-	1,300
Alcoholic Bev	1,239	41	56	31	71	171	448	143	177	2,377
Timber	1,497	7	524	7	41	9	3	1	-	2,089
Wool	2,433	0	17	83	13	1	7	0	-	2,554
Total	11,595	1,225	4,522	2,393	862	574	3,849	545	653	26,218

*includes live animals Source:- Department of Foreign Affairs and Trade Pivot Tables

Table 2 - Value of imports from some eastern seaboard countries – 2017/2018 - $Millions

Category/Country	China	USA	Japan	Thailand	Korea	World
Minerals & Fuels	$ 3,138	$ 2,218	$ 220	$ 1,256	$ 250	$22,922
Agriculture, Forestry, Fisheries	$ 1,562	$ 1,284	$ 4,020	$ 211	$ 5,395	$41,322
Manufactures	$72,499	$28,779	$16,597	$12,725	$ 6,237	$231,704
Other Goods	$ 1,046	$ 1,697	$ 1,414	$ 394	$ 566	$10,720
Total	$78,246	$33,978	$22,251	$14,587	$12,448	$306,668
Growth %pa 2006/7-2017/8	6.4%	2.0%	2.8%	4.5%	7.0%	4.7%

Source:- Department of Foreign Affairs and Trade Pivot Tables

These five countries are Australia's largest import partners accounting for 53% of imports. Four other Eastern seaboard counties (Malaysia, Singapore, New Zealand and Vietnam) account for another 13%. The value of agriculture related imports is shown in Table 3.

Table 3 - Value of agricultural-related imports – 2017/2018 - $Millions

Import	Value $millions	Growth Rate*
Petroleum products	$ 249.63	4.7%
Motor Vehicles and parts	$ 5,395.28	14.1%
Tractors and Farm machinery	$ 6,237.22	1.4%
Fertilizers and Insecticides	$ 565.99	1.6%

* Average 2006/2007 to 2017/2018 Source:- Department of Foreign Affairs and Trade Pivot Tables

3.1. The Competing Ports

The seven Australian ports, which handle the greatest value of export trade, are listed in Table 4

Table 4 - Australia's even busiest ports – Value of export goods handled - $Billions

Year	Dampier	Port Hedland	Melbourne	Hay Point	Newcastle	Brisbane	Sydney Ports	All
2006-07	$15.5	$6.8	$21.1	$10.4	$6.6	$10.4	$11.4	144.4
2015-16	$33.2	$26.3	$22.4	$12.1	$13.5	$13	$11.7	218.4
Growth	8.8%	16.2%	0.7%	1.7%	8.3%	2.5%	0.3%	4.7%

Source: BITRE – Australian Sea Freight – 2015-16

Possibly the greatest causes of uncertainty for freight exporters or importers in New South Wales are the questions of reliability of Port Botany, which is the possible cause of its slower growth.

The Port of Eden is the southernmost deep water harbour in NSW and is situated equidistant between Sydney and Melbourne. The Port provides a Harbour Master, 24 hour pilotage services, management of a Navy wharf and port security functions. There is also a deep inner anchorage.

The port also owns and manages an eight hectare cargo storage facility. The major users of the port are the Royal Australian Navy, wood chippers, and cargo ships for logs and cruise ships. The Port Charges include Navigation, Pilotage, Site Occupation and Wharfage and are competitively priced with respect to other Ports in New South Wales. There are frequent visits from some of the world's largest cruise ships.

Port Botany, the largest port in New South Wales, is the seventh largest in Australia but is growing more slowly than any other major port despite the fact that Australia's eastern coast ports handle about two-thirds of all freight and are growing faster than the average as shown in Table 5.

Table 5 - Eastern seaboard ports freight value $Billions

Year	Eastern Seaboard	Port Botany	All Ports	% Eastern Ports
2006-07	$ 90.0	$ 11.4	$ 144.4	62.3%
2015-16	$ 143.1	$ 11.7	$ 218.9	65.4%
Growth rate	5.3%	0.3%	4.7%	

Source: BITRE – Australian Sea Freight – 2015-16

Port Botany is geared to handle containers and imported fuel products, such as petroleum, bitumen, LPG and bulk chemicals. Rail is the major means of delivering containerized agricultural freight including grain, pulses, cotton and meat to Botany's three portside container terminals. It suffers from congestion and delays which impose financial and other penalties on exporters. Container volumes have historically been relatively volatile, leading to substantial uncertainty in their forecasts. However TfNSW forecast that annual growth in containers should be 2.5%[3].

[3] Source: TfNSW Freight Commodity Forecasts – 2016-2056

Port Kembla, situated in Wollongong and 90 Km south of Port Botany, also handles bulk liquids and has New South Wales' largest grain export terminal. It handles motor vehicle imports and mining product exports, such as coal. Port Kembla has been approved by the NSW Government as the site of NSW's next container terminal once Port Botany nears capacity.

The port at Newcastle is primarily a coal loading port but it has facilities for other types of cargoes. Recent initiatives to establish larger container handling facilities have been thwarted by a Federal Court decision so that this Port is limited to 30,000 TEU per annum (about 350,000 Tonnes). The relative importance of the various NSW ports is shown in Table 6.

Table 6 - Tonnage handled at NSW ports 2018-19 – '000 Tonnes

Port	Import	Export	Total
Botany	15,500	9,579	25,079
Newcastle	5,420	161,718*	167,138*
Kembla	8,412	7,820	16,232
Eden	-	263	263
Total	29,332	179,380	208,712

Source: Ports Australia Trade Statistics * Mainly coal

Export trade obviously depends on the frequency with which shipping vessels are available. Table 7 displays the current forecasts for vessel calls to Australian Ports.

Table 7 - Forecast numbers of vessels calling to Australian ports

Vessel Type	Year			% Growth	
	2007-08	2012-13	2029-30	08-13	08-30
Container Ships	7,161	6,910	11,200	-0.7%	2.1%
Bulk Carriers	14,439	15,500	23,100	1.4%	2.2%
General Cargo	3,633	3,710	4,080	0.4%	0.5%
Other	2,201	2,242	2,475	0.4%	0.5%
Total	27,434	28,362	40,855	0.7%	1.8%

Source: Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2010

The potential for Port Eden to attract shipping will depend on congestion at Port Botany, future plans for container facilities at Port Kembla, on the expected growth of shipping and the probability of Port Eden being developed to cope with an extra types and tonnages of freight handling. Coastal movement of non-containerized freight is expected to continue to grow steadily throughout the forecast period and improvements to Port Eden could attract some of this traffic.

3.2. The Potential for Passenger Travel

The potential for a regular passenger service to attract patronage encompasses commuting to Canberra and elsewhere for work, day-trips for business, commuting to Canberra for educational purposes, particularly TAFE and University, and general travel to Canberra and elsewhere for shopping, medical purposes or entertainment. The towns of Canberra, Queanbeyan, Michelago, Bredbo, Cooma, Nimmitabel, Bombala and Eden are located on the proposed rail route and would form the most probable primary rail passenger catchment,

although passengers from Bega, Merimbula, Pambula and other towns in the area may also seek the opportunity for rail travel to Canberra, Sydney and other parts of the catchment area, particularly the snow fields and coastal resort villages.

This patronage is modeled in the CARTS model. In addition, there has been an accelerating trend for residents to move out from Canberra into surrounding small towns in New South Wales. This is predicted to continue and, in addition, it is likely that any rail passenger service would induce further ex-urban relocation.

Tourism presents another major source for rail patronage, particularly snowfields patrons from Sydney and Canberra. About 17.7 million tourists visited the catchment area in 2020 as

shown in Table 8. They spent about $4.27 Billion.

Table 8 - Tourism in the catchment area - 2020

Region	Number '000	Expenditure $Mill	% Car	NSW Residents
South Coast	9,888	$ 1,326	93%	80%
Snowy Mountains	$1,158	$ 603	98%	76%
Riverina	$2,215	$ 427	92%	84%
Capital Country	$3,918	$ 819	93%	69%

Source: Destination New South Wales Note: LGA data has been compressed to Regions.

Tourism in the coastal areas is highly seasonal but the snow country peaks at different times than the coastal beaches. Given the high proportion of visitors who are residents of NSW and their dependence on car travel, the potential for attracting rail passengers is substantial.

Table 9 shows the primary socio-economic features of in regions in the catchment area. This data was collated by Local Government Areas but aggregated for brevity. The Riverina stretches from Carathool to Tumut, Murray from Albury to Wentworth and the South Coast region from Yass to Snowy Monaro.

Table 9 - Regional population and productivity of the catchment area

Region	Area SquKm	Popl 2018	Growth Rate	Regional Product $Mill
Riverina	70,546	171,156	0.87%	$ 7,347
Murray	78,972	116,117	-0.36%	$ 5,913
South Coast	51,673	227,876	7.09%	$ 9,819
ACT	2,358	414,400	4.05%	$ 39,440

Source:- NSW Govt. Health Statistics & ACT Government

This data, together with Local Government employment data is coded into the CARTS model to provide a basis for estimating passenger and tourism travel by road and rail.

3.3. The potential for freight movement

Similarly, major mineral, crop and other rural industry production in each Local Government Area is coded into the CARTS model to provide a basis for forecasts of freight movements to cities and ports by road, rail or intermodal travel.

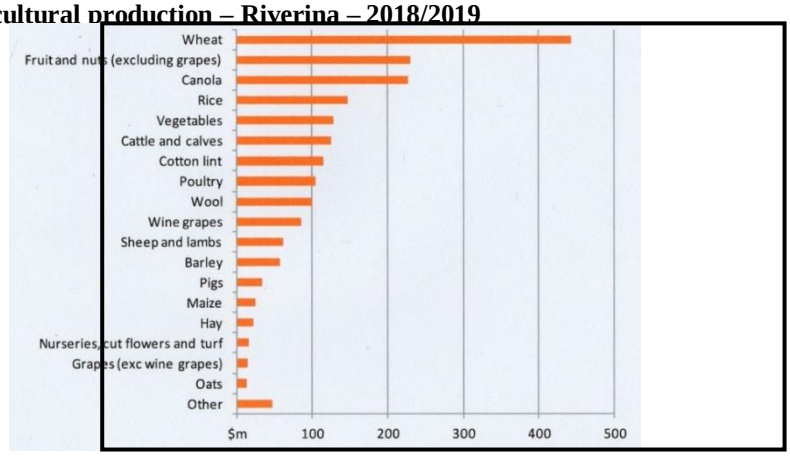
The location of ports, abattoirs and major grain-handling sites are also coded into the model as are major fuel distribution depots to aid in tracing movements from cities and ports to the rural towns.

In 2018–19, the gross value of agricultural production in the Riverina region alone was $2.5 billion, which was 21% of the total gross value of agricultural production in New South Wales ($11.7 billion). The value of each agricultural crop grown in the Riverina is shown in Figure 4.

At present all export wheat is carried to port by rail, some to Port Geelong and some to Port Kembla. Most rice, cotton and nut crops in the Riverina are currently forwarded to Melbourne.

NSW yearly produces 52 kilotons of rice, 755 kilotons of cotton lint and seed, and 4,750 kilotons of wheat. Regional NSW supplies agricultural commodities, food and beverages to the world's largest and growing consumer markets in Asia, the Pacific Rim and Europe. Table 10 shows the value and growth rates of rural production in New South Wales.

Figure 4 – Value of agricultural production – Riverina – 2018/2019



Source: Australian Bureau of Statistics, cat. no. 7503.0, Value of agricultural commodities produced, Australia 2020

Table 10 - Value of NSW rural produce

Agricultural Industry	$Millions pa	Growth rate
Cropping	$ 2,498	Variable
Meat	$ 4,671	4.0%
Livestock products Incl. Wool	$ 2,062	4.0%
Fishing	$ 181	2.1%
Food products	$ 30	5.0%
Wine	$ 2	Variable

Source: 'NSW Primary Industries – Performance, Data and Insights 2019'

There are about 70 cattle farms and/or Feedlots in NSW. Cattle in the Riverina are currently processed through Wagga Wagga but the Abattoir at Cootamundra is due to reopen. China buys about 80% of wool grown in New South Wales and is the fastest growing market for beef from New South Wales – 35% but growing at about 33% per annum. China buys 51% of all Australian dairy product exports and there is further potential for the export of Dairy produce from the Bega and the Murray-Goulburn areas where producers are already exporting

dairy produce. Exports of NSW wines totals more than $520m, which makes it NSW's 4th largest primary industry.

In 2019-20, NSW timber product exports were $181.4 million, up 9%. China was the largest destination, with exports valued at $158.3 million (up 12%), followed by Taiwan ($9.4 million, up 13%) and South Korea ($5.5 million, up 11%)[4].

The population forecasts are based on several sources and reflect several influences on growth. Table 11 provides several key NSW forecast indicators. Overall the Intergenerational Report forecasts that Australia's population will grow more slowly and age faster than expected earlier.

Table 11 - Key NSW forecast indicators

Year	2018-19	2030-31	2040-41	2050-51	Growth 2019-51
Population '000	8,087	8,960	9,835	10,688	0.88%
% 65 and Over	16.3%	20.3%	22.0%	23.3%	1.12%
% Employed	50.4%	50.4%	50.7%	50.2%	n.a.
GSP $Billion	$ 629	$ 984	$ 1,566	$ 2,430	4.32%
GSP/Capita	$ 77,779	$ 109,821	$ 159,227	$ 227,358	3.41%

Source: NSW Intergenerational Report 2021-22

The Local Government population forecasts are affected by a number of factors:-

- Rural populations are ageing faster and are older than urban,
- Increasing housing prices in the larger cities, especially Canberra, have induced a shift in population to rural towns,
- The more remote towns lose their younger members so that the smaller towns have been losing population while the larger ones have been growing faster than the State population,
- The pandemic has imposed restrictions on immigration, with flow-on effects on ex-urban migration., and
- The pandemic has affected International student intake with effects major regional cities with tertiary campuses.

The rural industry forecasts for the probable catchment area are fraught with difficulties. The climate and labour factors creating forecast uncertainty include:-

- Droughts in recent years, so that less wool, livestock and grain is carted to markets and abattoirs, while stocks are rebuilding,
- Bushfires and flooding,
- Yields are down for all crops,
- There have been shortages of seasonal labour,
- There have been problems with live cattle exports,
- Diplomatic relations have affected trade agreements,
- In addition several pricing factors have affected the costs of production,
- The price of fuel has risen sharply during the past few years,
- Freight vehicles are now carrying heavier loads as more roads are designated for B-Doubles, which has resulted in reduced freight prices, and
- The fluctuating value of the Australian Dollar has affected export and import prices.

[4] NSW Department of Primary Industries

Table 12 provides forecasts for various rural commodities produced in New South Wales.

Table 12 - Regional NSW freight commodity demand forecasts, 2016-2056, mtpa

Commodity	2016	2036	2056	Growth Rate	Total Increase
Grains	8.4	10.6	12.9	1.1%	54%
Oilseeds	1.3	1.7	2.1	1.2%	62%
Edible oils	0.2	0.3	0.4	1.7%	100%
Livestock meals	0.5	0.7	0.9	1.5%	80%
Livestock	1.4	3.1	3.9	2.6%	179%
Red meat	0.6	1.3	1.6	2.5%	167%
Horticulture	1.5	1.8	2.2	1.0%	47%
Forestry	3.2	3.4	3.2	0.0%	0%
Cotton lint	0.4	0.5	0.7	1.4%	76%
Dairy	2.2	2.8	3.5	1.2%	60%
Grapes and wine	0.8	0.9	1.1	0.8%	38%

Source: TfNSW Freight Commodity Forecasts – 2016-2056

These forecasts were coded into the CARTS model for each LGA. Some of this production is consumed domestically. For instance some grains are fed to cattle in feedlots and some is used by consumers at home. Table 13 provides some guidance on domestic consumption and the transportation method for NSW Grains.

Table 13 - Forecast of consumption and transportation for New South Wales grains - mtpa

Transportation	User	2016	2036	2056	Growth Rate	Overall Growth
Bulk	Domestic	4.6	6.2	7.6	1.26%	65.2%
	Export	2.6	2.7	3.2	0.52%	23.1%
Container		1.1	1.7	2.2	1.75%	100.0%
	Total	8.3	10.6	13.0	1.13%	56.6%
% Exported		45%	42%	42%		

Source: TfNSW Freight Commodity Forecasts – 2016-2056

It is important to know the proportion of each rural produce which is exported because the CARTS model consigns export production to the ports in New South Wales and it is assumed that each port has the necessary bulk and/or container handling facilities. Domestic consumption, after farm or local retention, is consigned to the various cities and towns in New South Wales.

The CARTS model recognizes that some part of each consignment may be by road transport and then by rail. It is designed to assign freight in at least two stages. Thus it can, for instance, model cotton being carried by truck to a loading bay and then being railed in containers to port. Or conversely it can model fuel being railed in bulk from port to a fuel depot and then being delivered by road tanker to service outlets.

4. Passenger and freight demand modeling

In estimating and forecasting freight movement the CARTS model assesses three different forms of movement namely:

- the movement of agricultural goods from each rural zone to its nearest market or processing zone and then, after allowing for local consumption, the movement of processed farm produce to the nearest port for export. The freight tonnage moved from farm to market is reduced to allow for weight loss due to processing for export before it is moved from the processing zone to port. Agricultural freight tonnage accounts for a large proportion of rail freight movement in this area,
- the reverse movement of imported goods, such as fuels and oils, fertilizers, steel for construction and general supermarket or packaged goods, from the ports in New South Wales to the inland population centres, distributed through the main business zones, and
- the movement of locally produced goods from the manufacturing centres to other population centres.

4.1. Road / Rail competition

The CARTS model estimates the extent of road / rail competition by comparing the pricing of road and rail freight movements. It then applies elasticity data to assess the degree to which reductions in the price of one mode affects the freight shifted from the other mode. Pricing includes the estimated value of delays and loss or damage to freight as well as the actual loading and carriage charges.

Choice for freight travel is partly determined by the availability of loading/unloading and storage facilities and charges, delivery time and costs, potential risk of breakages or loss and the reliability of services. Table 14 shows the cross freight elasticity values used to assess the degree to which changes in the perceived rail prices would lead to transfer of freight from road to rail over various distances.

Table 14 - Long-run road/rail freight cross-elasticity

Mode	Short-distance		Medium-distance		Long-distance		All corridors	
	Road	Rail	Road	Rail	Road	Rail	Road	Rail
Road	–0.36	0.35	–0.43	0.33	–1.08	0.66	-0.46	0.58
Rail	0.88	–0.93	1.08	–1.15	0.42	–0.78	1.04	–1.66

Source: BITRE estimates.

These pricing components vary between commodities and whether they are forwarded as container, bulk or general cargoes. Similarly, the choice of mode for container or bulk freight is different from perishable or refrigerated freight, where access and travel times are dominant. Each commodity group is priced in the model for both freight modes. Most commodities are initially carried by truck and then may involve intermodal handling. The model provides for two-stage consignment from mode to mode. Of the export commodities grown in the catchment area, food grains (wheat, barley, maize etc), timber (woodchips, logs etc), cotton and wool are usually bulk cargoes but dairy products, wines[5], canned vegetables and meat products (with the exception of live cattle) are carried in containers. All of these commodities may be initially carried by truck but are potential rail freight markets, although live cattle and woodchips may be loaded directly onto railcars. Some then go to a silo or railhead.

[5] McWilliams wines in Griffith ship grape juice by rail to Sydney for bottling before exporting.

4.2. Rail freight to Port Eden or other ports

The CARTS model estimates the degree to which Port Eden attracts freight traffic from other Ports by comparing the freight pricing from its origin to other Ports in NSW. The "price" perceived by forwarders includes not only the estimated cost of direct access, storage, loading, insurance, rail and port charges but also weighting for uncertainty, delays and damage to goods. It then applies elasticity data to assess the degree to which reductions in the price of each port affects the freight shifted from another port to Port Eden.

The CARTS model was carefully calibrated to replicate travel conditions in New South Wales. The predicted traffic assignments to the road network were compared with actual traffic counts provided by the Roads and Traffic Authority. The traffic assigned to the road links in the network consists of trucks carrying rural produce, trucks carrying general freight and other vehicles primarily carrying passengers. Travel elasticity varies with trip length so the model was also calibrated against trip length frequency data.

Truck and freight movement is predicted separately from passenger travel, which is predicted from each zone to every other and depends on its population, its vehicle ownership, the employment available at the destination zone and the perceived travel price between them. Of particular interest is the calibration of traffic to the various NSW ports. This is shown in Table 15. As the future for coal mining is uncertain, coal exports from Newcastle have been omitted.

Table 15 - Calibration of port average annual tonnages - '000

Port	Actual 2018-19	Estimated 2021	Modeled 2021
Botany	25,079	25,230	24,950
Newcastle	10,840*	9,470*	11,900*
Kembla	16,232	17,896	18,700
Eden	263	284	300

Source: TfNSW and CARTS model Note: *excludes coal exports

The current road traffic on the Monaro Highway, which parallels the rail line, is of obvious interest. Table 16 shows that heavy vehicle traffic on the Monaro highway at Bredbo is increasing rapidly.

Table 16 - Average daily two-way traffic on Monaro highway at Bredbo

Year / Growth %	2017	2015-17	2021	2017-21
All Vehicles	4,857	0.82%	4,900	0.22%
Heavy Vehicles	550	2.87%	833	10.94%

Source; TfNSW traffic counts

About 7,000 people travelled in light vehicles through this count station each day and about another 170 travelled in buses. The average car-occupancy was 1.72. The traffic counts at Bredbo also show that approximately 12 thousand tonnes of freight was carried by road that day or about 3.4 million tonnes per annum.

Table 17 shows the type of freight carried in trucks past the station at Bredbo. Many of the empty trucks were returning for quarried stone and gravel loads. Most of the trucks of greater than 12 tonne tare were B-Doubles and sand, stone and gravel bound for Canberra accounted for about 0.6 Million tonnes per annum.

Table 17 - Freight types carried past Bredbo count station

Freight Type	%
General freight/ Bulk	38.7%
Stone, Gravel Building Materials	21.3%
Fuel, Gas	7.1%
Machinery, Vehicles	7.1%
Containers	3.9%
Livestock, Hay	3.2%
Passenger Coaches	2.6%
Timber	1.3%
Empty, Part empty	14.8%
Total	100.0%

Source: Counts during this study

5. The modeled freight and passenger forecasts

The model forecasts for future freight tonnages to New South Wales ports in the modeled years are shown in Table 18.

Table 18 - Forecast freight average annual tonnages at NSW ports – '000

Port	2021 Before+	2021 After	2036	2051	Growth rates	
					2021-36	2036-51
Botany	24,950	23,900	25,000	26,100	0.30%	0.28%
Newcastle	11,900*	11,700*	18,550*	26,850*	3.12%	2.50%
Kembla	18,700	17,900	25,200	27,100	2.30%	0.50%
Eden	300	2,350	6,500	13,950	6.97%	5.26%
Total	55,850	55,850	75,250	94,000	2.00%	1.50%

Source CARTS model Note: *excludes coal exports +Without the railway

Table 19 provides the CARTS model estimate for the passengers which would travel by a daily rail service on each leg from Canberra to Eden.

Table 19 - Forecast average daily two-way rail passenger loads

Journey leg	Year		
	2021	2036	2051
Canberra-Cooma	515	830	1,180
Canberra-Bombala	140	230	330
Canberra-Eden	40	70	90
All Passengers	700	1,130	1,600

Source: CARTS model

Approximately 7.8% of car travellers and 90% of bus travellers are expected to be diverted to travel by rail. It is estimated that two passenger trains each way per day would be necessary to accommodate this traffic.

Some freight will still be transported to Port Eden by truck. Table 20 shows the forecast amount of freight bound for Port Eden by each mode.

Table 20 - Mode of freight access to Port Eden – Tonnes '000 pa

Mode	Year		
	2021	2036	2051
Truck	300	650	1,150
Rail	2,050	5,850	12,800
Total	2,350	6,500	13,950

Source; CARTS Model

It is estimated that up to five freight trains each day could be necessary to accommodate this traffic by the year 2051.

6. Validating the passenger and freight forecasts

Despite the model calibration, which may reflect current operations sufficiently well, the forecast socio-economic conditions and the forecasts for agricultural and other rural production involve a large number of assumptions. This leads to considerable risk in trusting the forecasts. It was therefore considered necessary to conduct a series of field interviews, with freight producers, forwarders, carriers and stevedoring companies, intended to checking the model's assumptions about rail operations, pricing, transit time, frequency and other service characteristics.

The interviews also sought to confirm, or otherwise, the assumptions regarding the potential growth in rural production and the assumptions built into the perceived freight pricing. They also recognized that the freight forecasts are largely dependent on the ability of the proposed rail line to induce commodity exporters to either;-

- transfer from truck haulage to rail, or
- transfer exports/imports from other ports to Port Eden or
- Produce more goods for export.

As an overall indication of the value of transport improvements in helping industry to grow, freight producing businesses surveyed in Griffith reported that freight damage or delay caused total losses of about 2% of their annual turnover. The local freight industry's turnover was just under 6% of the annual turnover of these businesses. The businesses interviewed estimated that, if freight cost, delays and damage could be reduced by 20%, they would be able to expand their business turnover by almost 3% more than their current marketing plans.

This value of this induced production would be 2.4 times the cost of the improvements in transport services. Producers clearly would respond to improved freight services.

Excello, Nugan Quality Foods and Parle Foods use rail for export and reported that they have plans for growth in their export markets. It was also reported that those rice, cotton and nuts growers in Murray Shire and the lower Riverina were seriously restricted through the lack of rail services and currently trucked their produce to rail services in Victoria.

Rail dominates the export freight market and its market share is about 80%. Most of the exporters used rail and reported that they were satisfied with their service. They included grain and wine producers and some manufacturing firms. In summary, road transport has about a 17% cost advantage over rail for domestic freight in the region but rail has about a 7-8% cost advantage over trucks for the export market.

It is estimated that the rail advantage for exports could increase to a minimum of about 9.5% for shipment at Port Eden from areas in the catchment area.

Several rail users complained about the lack of flexibility due to the short windows of access to Port Botany. This is exacerbated by traffic congestion through Sydney on route to the Port. There were frequent mentions of their complete dependence on Port Botany for container export and the lack of choice and strategic resilience when incidents happened at that port.

Logs and wood chips are shipped from the ANWE wharves at Port Eden. A representative of the timber industry confirmed that supplies were devastated by the 2019-20 bushfire season, with more than 50,000 hectares of the state's pine plantations burnt. Regrowing has commenced with more than 14.5 million trees to be replanted yearly across the State from 2021[6]. Timber companies are at present working at capacity prematurely stripping burned timber.

Interviews with the Eden Harbourmaster and others using the port confirmed after inspection that the harbour could be expanded with adequate draft and wharf space to accommodate the largest expected ships. Interviews with Eden Chamber of Commerce people confirmed that the town of Eden is willing and able to accommodate an expanding workforce and the cruise ship market.

It became clear during these interviews that, until sufficient liner shipping with diverse international destinations called at Port Eden, the shipping of containers might initially be restricted to deck cargo on bulk carriers. However, as bulk loads have a uniform composition and a single destination, shipping schedules are not a limitation on bulk loads being forwarded from the Eden harbour. Several freight consumers and producers expressed their enthusiasm and willingness to cooperate if a multimodal terminal were developed in Canberra.

7. Economic, risk and financial evaluation

The benefits of the project, which are valued in perceived prices, include all of the following:-

- Personal travel benefits, including tourism,
- Induced residential relocation benefits,
- Freight movement benefits,
- Induced rural industry production benefits, and
- Induced export or import replacement benefits.

The resources consumed or saved, which are valued in resource prices, include the following:-[7]

- The total implementation cost, including track, rolling stock, stations, signalling and that part of the port expansion cost which is due to rail,
- Changes in annual road and rail maintenance8 costs,
- Changes in annual road accidents,

[6] Minister Barilaro press statement

[7]The value of time, accidents, vehicle operating, road maintenance and environmental impacts are taken from NSW Guidelines

[8] The unit costs for rail operations and maintenance are taken from the Concept Plan Part 3A

- Changes in annual train and vehicle operating costs,
- Changes in emissions, and
- Changes in annual transport user travel time.

Induced residential relocation benefits – There is an existing trend for people to relocate out from the major cities due to the high prices of housing. These movements do not create added benefits for the project other than their use of passenger rail services. However, the increased accessibility created by the project will induce more people to relocate. Their relocation benefit must be at least equal to their net perceived cost of the added travel they incur.

Freight movement benefits - The transporters of freight and supplies benefit through transport improvements. This mechanism involves reduced perceived transport costs for freight carriers through a reduction in delivery times, portage, improved reliability and reduced damage to goods, or the ability to gain greater vehicle fleet utilisation through reduced travel times or down-time.

Induced rural industry production benefits[9] - If the price or uncertainty of freight movement can be reduced, then people will be induced to produce more. These cost reductions are partly passed on to consumers in the form of lower freight prices and, if this is so, this can result in higher rates of general consumption for these goods. The freight industry is sufficiently competitive that cost reductions normally translate into freight price reductions. This form of benefit is estimated from the marginal additional production induced by reduced farm-gate prices for freight due to transport improvements. Part of this increased rural production is exported and, as this adds to the general national wealth creation, and does not displace production in other areas, an additional benefit can be attributed to the project. This is valued at the ex-port net value at export prices less all production and transport costs[10].

The construction cost includes track, signaling, earthworks, bridges, tunnels, land acquisitions, stations and other civil works, including a part of the cost of the port improvements. Other rail costs include rail rolling stock, track maintenance and train operating costs, which have been adopted from the concept plan reports. The financial and economic prices are shown in Table 21. P50 contingency costs are included but other contingencies are dealt with in the risk evaluation.

Table 21 - Financial and economic costs ($Millions)

Rail cost item	Implementation	Rolling Stock	Op Costs	Maintenance
Financial price	$ 2,540	$ 2.800	$ 7.980	$ 7.662
Contingency (P50)	$ 272	$ -	$ -	$ -
Taxes etc	$ 395	$ 0.336	$ 0.718	$ 0.996
Economic price	$ 1,873	$ 2.464	$ 7.262	$ 6.666

Source: "Concept plan for Canberra to Eden railway Part 2 - Preliminary estimate of construction costs".

Improvements to the port at Eden may induce road freight movements, even if the rail project does not proceed. Testing showed that there were benefits to freight handlers and there were

[9] WORLD BANK (1976). Technical working paper No. 241. International Bank for Reconstruction and Development, Washington.
[10] See also R J Nairn, "Producer Surplus in Transport Economics", ATRF 2022 for more details.

savings in road maintenance, road accidents and vehicle operating costs. User time costs were minor.

Rural production was forecast to increase by 6.8% in the catchment area as a result of the improved port facilities. The results are shown in Table 22.

Table 22 - Benefits from opening Port Eden for truck traffic with no rail - $Millions

Road Maintenance Costs	$6.20
Accident Costs	$2.10
Vehicle Operating Costs	$11.00
Freight Benefits	$27.50
Rural Industry Benefits	$30.30
Net Benefits $millions	$38.50

Source: CARTS model

Thus it is estimated that approximately half of the cost of the improvements at Port Eden would be justified if it were fully provided with facilities for road traffic alone. The result of the economic evaluation for the Rail Proposal is shown in Table 23.

Table 23 - Economic evaluation results for the rail proposal

NPV of Costs and Benefits -$Millions *		**Discount rate**		
		3.0%	**3.5%**	**4.0%**
Rail and Port Construction Cost		$ 972.7	$ 1,050.9	$ 1,114.3
Road System	Maintenance Savings	$ 6.4	$ 5.9	$ 5.5
	Accident Costs Savings	$ 147.3	$ 135.7	$ 125.3
	Veh Op Costs Savings	$ 1,062.6	$ 977.6	$ 901.0
Rail System	Rail Operating Costs	$ 326.6	$ 297.8	$ 272.1
	Rail Rolling Stock	$ 18.6	$ 17.9	$ 17.2
	Rail Maintenance Costs	$ 117.4	$ 108.8	$ 100.9
User	User Time Savings	$ 159.2	$ 146.4	$ 134.9
	Consumer Surplus	$ 148.7	$ 136.8	$ 126.1
Public	Relocation Benefit	$ 8.4	$ 7.7	$ 7.1
	Environmental Savings	$ 93.7	$ 87.6	$ 82.0
Industry	Freight Industry	$ 225.1	$ 205.6	$ 188.2
	Rural Industry	$ 207.9	$ 191.4	$ 176.5
	Induced Exports	$ 91.6	$ 83.3	$ 75.9
Net Present Value NPV		$ 715.4	$ 502.6	$ 317.8
Benefit-Cost Ratio		$ 1.50	$ 1.34	$ 1.21

Source: CARTS model * Residual values included in perpetuity

Consumer surplus benefits are those derived in the usual way from passenger movements. Freight industry benefits are those not passed on to freight customers. Rural industry benefits are those passed on to local industry, wheras induced export benefits are those derived from exports or import replacements.

These results show that the rail proposal is marginally feasible, with an Internal Rate of Return of 4.86%, provided that discount rates remain low.

Risk analysis recognizes the probability that some combinations of individual variations in important assumptions used in the modeling process may compound each other.

A Monte Carlo approach was used to assess the maximum and minimum variability of a range of input factors and randomly selecting their effect on the economic result. The risk evaluation model provided the potential risk outcomes as shown in Table 24.

Table 24 - Risk evaluation results

Risk analysis results	Internal Rate of Return	Benefit-Cost Ratio @ Rate		
		3.0%	3.5%	4.0%
Modeled Results	4.88%	1.50	1.34	1.21
Risk Adjusted Results	**4.56%**	**1.29**	**1.17**	**1.09**
Maximum probable	4.72%	1.34	1.13	1.13
Minimum probable	4.31%	1.18	1.06	0.98

The risk results show that the most probable outcome is an Internal Rate of Return of 4.56% but with a possible worst case of 4.31% and a possible best case of 4.72%. Discount rates higher than 3.8% would possibly make the project too risky.

The project should return a financial IRR of 4.96% and, provided it can be funded at 3-4% interest rate, it should be profitable. It should begin to pay off debt by 2027 and have paid off all debt by 2048 if the project is completed by 2026. The project would not be financially viable if the borrowing rate was 5%.

8. Conclusions

The fundamental purpose of all investment in transport is to foster economic growth through improved freight productivity and service quality (including improved reliability and resilience), to optimise environmental outcomes and to assist regional social and economic development.

If additional rural production is induced by the transport improvements there are added benefits to the project, particularly if the induced production is for export or import replacement. During the study many export producers indicated that they could and would expand their international markets and sales if they had access to improved rail services to ports. Where the data available allowed this to be measured it confirmed that the added value to the nation's economy far exceeded the costs of the required transport improvements.

This paper illustrates a methodology for modeling passenger and freight movements in a State-wide rural network with emphasis on encouraging rural export freight to ports. The modeling process is much more complex than modeling urban traffic and the forecasting assumptions necessary to build into the models are much more diverse and subject to question so that risk mitigation calls for on-site investigations and interviews to validate the modeling process.

The interviews conducted during this study also identified many risks which were not directly associated with the modeling procedures and which led to revisions in the assumptions. They clearly showed the absolute need for on-site validation of the modeling.

9. References

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