The Value of Rail in New Zealand –

2016

For the NZ Transport Agency

Building a better working world

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1. Executive Summary

Rail in New Zealand

The rail networks in many countries can be considered as natural monopolies due to their large fixed set up costs presenting barriers to entry for other potential market participants. This is also the case in New Zealand, as large rail infrastructure is stretched throughout both island's geographically challenging landscape. Natural monopolies can become significant economic enablers and they often have some form of government involvement. This is no different in NZ and the constant question which has been raised is *how much involvement should the NZ government have in the natural rail monopoly, KiwiRail*?

Purpose and Scope of Analysis

EY have been engaged by the New Zealand Transport Agency (NZTA) to investigate if the Value of Rail to the wider transport system is greater than the commercial return and subsidy support it receives. This is needed so more informed decisions can be made about how New Zealand allocates its scarce resources across the transport system (especially road versus rail trade-offs) to ensure that NZ has the most economically efficient transportation network.

The scope of this study is to investigate the Value of Rail which encompasses Auckland and Wellington passenger services and KiwiRail's national freight service. This study does not include any analysis on KiwiRail's non-rail assets, for example the Interislander ferry and property portfolio are not included. This is also not a financial analysis where KiwiRail's cash flows would be discounted to determine a company valuation, it is an economic analysis that investigates the economic costs and benefits of rail to determine the 'Value of Rail'.

It is intended that the Value of Rail calculated will provide a broad indication of size and magnitude, and it is not our intention that this will be viewed as a final precise Value of Rail. A range of 'Next Steps' have also been suggested (later in this report) that will improve the precision of this proof of concept value and chosen methodologies.

High level methodology

Throughout this study we have consulted with stakeholders regarding the most acceptable approach to analyse the Value of Rail. This study's comparative static approach and high level methodology has been met with a general consensus from the stakeholders NZTA and KiwiRail.

The comparative static approach compares the current state to a situation where freight and passengers are transferred to road from rail and any extra economic cost imposed in this scenario is equal to the benefit of rail less the economic savings made from the discontinued use of rail. No discounted analysis has been undertaken as it is a static analysis for one year only.

We have broken down our comparative static analysis in the following manner

- Quantitative Analysis
  - ✓ Congestion benefits
  - ✓ Maintenance benefits
  - ✓ Safety benefits
  - ✓ Emission benefits
- Qualitative Analysis
  - ✓ Connectivity benefits
  - ✓ Land Use and Value Uplift benefits
  - ✓ Resilience benefits

Within each segment of the quantitative analysis, there exist limitations often due to lack of information. To navigate through these limitations, conservative estimates have been made to arrive at a value.

Findings Summary and Implications

This study has calculated the total Value of Rail to be approximately $1.54b to $1.47b, this value includes net benefits from congestion time delays, safety, maintenance and emissions. As seen in the table below congestion time delay benefits of rail make up the majority of total benefits. In turn a large proportion of these congestion benefits are made from avoided time delays in Auckland and Wellington as a result of passenger rail.

Value of Rail

Sensitivities are ± 2% of certain inputs, detailed in later sections	Passenger	Freight	**Total**
Net Congestion Benefit of Time Delays	$1,186m – $1,140m	$207.56m – $200.27m	**$1,394m – $1,340m**
Net Safety Benefits	$8.28m- $3.97m	$60.50m - $56.24m	**$68.78m- $60.21m**
Net Maintenance Benefits	-$14.43m - -$13.87m	$80.39m – $77.23m	**$65.95m - $63.37m**
Net Emission Benefits	$3.00m- $2.66m	$6.27m- $5.79m	**$9.33m – $8.49m**
Total Net Benefits	**$1,183m - $1,132m**	**$354.72m - $339,53m**	**$1,537m- $1,472m**

We expect the qualitatively analysed benefits, Connectivity, Land Use and Value Uplift and Resilience to significantly lift the estimated $1.54b to $1.47b public value if they were to be quantified.

The implications of these findings for passenger rail is that the support it receives from subsidies (central and local government) is highly likely to be acceptable because passenger rail is calculated to add significant value by reducing congestion on Auckland and Wellington's arterial roads. The implications of these findings for freight rail is that the government funding it receives is likely to be acceptable as the total benefits (both quantitative and qualitative) could be greater than the government support it receives. To confirm that freight rail's benefit outweighs its government support, more accurate heavy commercial vehicle transport modelling and a quantitative resilience analysis is needed.

Limits of Analysis

It is not intended that the reported values should be used for determining whether certain rail corridors should remain open, closed or mothballed as this study's analysis is of the whole rail network (in its current state versus without rail). Any attempt to determine the value of an individual corridor of rail should be done separately, although parts of this study's methodology may be used. Our analysis includes conservative assumptions and may only apply for the current period of time and under certain operating conditions (e.g. existing rail freight moved, load of average truck) and therefore results should not be extrapolated. This report does not value resilience, connectivity or land use and value uplift characteristics caused by rail, however these are important factors that later studies should consider quantitatively.

Caution should be exercised around the use of congestion figures for freight, as heavy commercial vehicle travel times have been estimated conservatively. Caution should also be exercised across all quantitatively analysed results as no behavioural impacts have been accounted for in our static analysis.

2. Introduction

Rail networks have long been thought of as possessing natural monopoly characteristics as they have high up-front infrastructure costs and significant barriers to entry. Because of these characteristics, natural monopolies often create an expectation that the state will have a major stake in the provision of the service.

While the expectations for some form of government involvement is clear, what is less clear, and is often the centre of much debate, is the *extent* to which governments should be involved. Is full ownership desirable? Is partial ownership desirable (separation of above-ground and below-ground assets)? Is privatisation with appropriate regulation desirable?

The experience of KiwiRail is a live embodiment of this debate with several operating models being experienced over the past thirty years from full public ownership to full privatisation.

The current operating model lies towards the 'public ownership' end of the spectrum with KiwiRail being run as a State Owned Enterprise[1] and receiving a direct capital investment from central government every year (most recently through Budget 2015), Rail metro services in Wellington and Auckland also receive subsidisation through regional council rates and from the National Land transport Fund (NLTF).

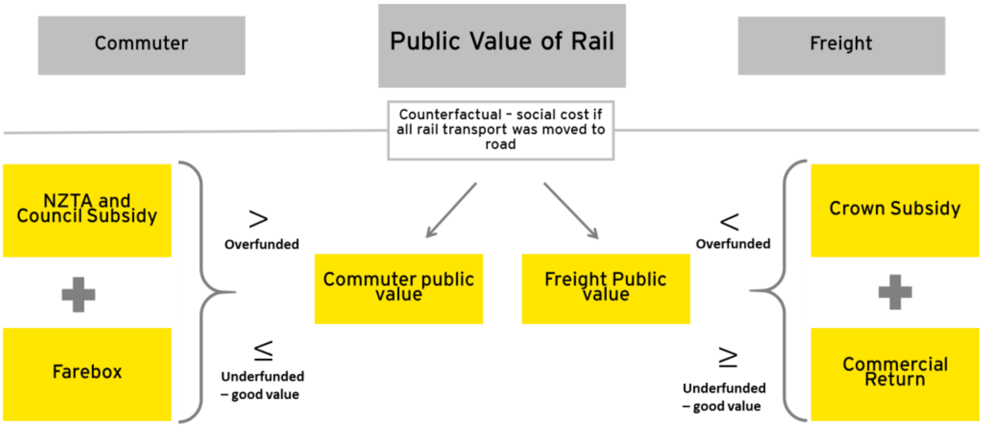
To better understand the extent that central government should interest itself in the provision of rail in New Zealand, it is prudent to understand the public benefits that accrue from rail. This will help support the rationale for continued intervention or provide a basis for the retreat from financial support for rail.

[1] A State Owned Enterprise is a legal entity that is created by the government in order to partake in commercial activities on the government's behalf.

2.1 Scope

EY ('We' or 'Our') have been engaged by the New Zealand Transport Agency ('the Transport Agency' or 'You') to develop an understanding of whether the public value that the rail network and operations brings, is greater than the current combination of KiwiRail's commercial returns, plus any support/subsidy through a combination of National Land Transport Fund (NLTF) subsidies for public transport and direct Crown funding. A stylised version of our scope is outlined in Figure 1.

Figure 1: A stylised version of the engagement



2.2 General approach

Our general approach to this engagement has been to model the effects to the road network if there was no rail network – i.e. what would be the potential economic cost to New Zealand from no rail network.

This approach explicitly does not consider any issues surrounding mothballing or disposal of the existing network. Nor does it consider any second-order or behavioural effects that might result from more vehicles being on the road. In this sense, the findings can be considered indicative and helps create and understanding of scale and magnitude of the Value of Rail.

In calculating the indicative economic benefits (or avoided costs), we have actively engaged with major stakeholders throughout this study, including:

- Holding several workshops with stakeholders from: KiwiRail, the Transport Agency, Ministry of Transport, Treasury, Greater Wellington Regional Council and Auckland Transport.
- Holding discussions with, and sourcing key operating information from, KiwiRail throughout this process.
- Utilising actual transport model outputs from Auckland Transport and Greater Wellington Regional Council to populate our model.

We have also drawn on a wide body of international and domestic literature on the Value of Rail to help nuance some of our initial findings.

2.3 Limitations

We understand that the data we have used and the analysis we have completed has some limitations that should be considered. With each limitation, where possible this analysis has erred on the side of caution and made conservative estimates to produce a calculation. Listed below are the major limitations of this study's analysis and within each segment of Section 4 (below) more specific model/ calculation limitations are presented. These limitations represent cautions as to how the models outputs should be analysed.

Transport Model Outputs Limitations:

- The Auckland Transport model produced travel times and distances far lower than expected and after discussions with AT it was hypothesised that models inputs should have been applied on a corridor by corridor basis rather than a whole of network approach.
- Heavy vehicle journey times with and without rail for the metro congestion calculations have been assumed to be the same as light vehicles. This is conservative as generally heavy vehicles cause more congestion as they are slower.
- Intercity freight delays were estimated by using a calculated delay time per km over all road network sections that would be used if rail was removed. Conservative estimates were made to ensure delay times are not overstated.

Behavioural Analysis Limitations:

- This study has not taken into account any behavioural analysis that would take place from the immediate removal of passenger and freight from rail. This would reduce the net social benefit of rail we have calculated as freight operators and rail passengers would adapt their behaviour to reduce the congestion they faced (for example leaving earlier or later to avoid delays or possibly working from home). It is not this study's aim to estimate the exact social benefit but to provide a value that indicates the scale and magnitude of the benefit which can be appropriately calculated without including behavioural changes.

Maintenance Calculation Limitations:

- Existing cost of rail infrastructure includes the costs of the 'above the line assets' as no factor could be found to segment cost into 'below the line' and 'above the line'[2]. By not segmenting this cost our approach is conservative as in the event of the immediate removal of rail, 'above the line' maintenance costs (e.g. maintenance on rolling stock) would be transferred to maintenance on trucks and only savings on 'below the line' assets would be realised.

[2] Below the line = signals, tunnels, bridges and the rail track
Above the line = locomotive, carriages, wagons, staff, ticketing systems.

Rail Freight Data Conversion Limitations

- A flat conversion rate has been applied to convert tonnes on rail to number of trucks (or TEUs). This conversion factor is the average tonnes carried by a truck. Our model does not use different conversion factors for transporting different load types due to a lack of data availability, though in reality different materials can be transported at different weights. The conversion factor used was based on values extracted from a NZTA[3] truck load factsheet.

The contents of this report is not designed to be relied upon for any specific negotiations about the appropriateness of the existing subsidy, but will help promote a dialogue around whether there is an unaccounted value of rail that should be incorporated into decision-making on future investment and support. This study's assumptions and results may differ from previous economic analysis, a reconciliation between these studies and ours has been made in Appendix E (however this is limited to availability of information).

[3] NZTA Vehicle dimensions and mass fact sheet (2013)

3. Operating Environment

3.1 KiwiRail

KiwiRail is a State Owned Enterprise which owns and operates New Zealand's rail transportation network and the Interislander ferry service.

KiwiRail consists of:

- **KiwiRail Freight** which provides rail freight services as well as locomotives and locomotive engineers for some passengers services.
- **KiwiRail Interislander** operates the Cook Strait ferry passenger and freight services.
- **KiwiRail Passenger Scenic Journeys** operates long distance passenger train provided on Coastal Pacific, TranzAlpine, Northern Explorer and Capital Connection services.
- **KiwiRail Infrastructure and Engineering** maintains and improves the rail network and controls the operations of trains on the network. It also services locomotives and rolling stock at Hutt workshops.

3.1.1 Corporate overview

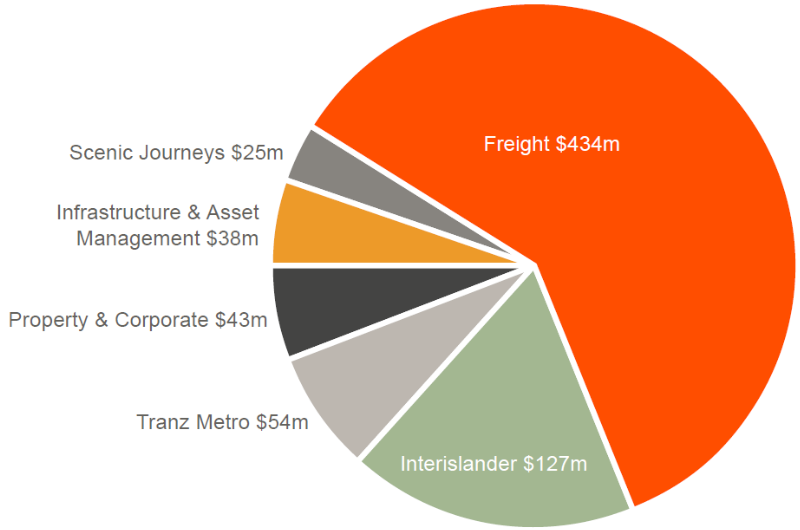
The principal objective of every State Owned Enterprise is to operate as a successful business and, to this end, to be as profitable and efficient as comparable businesses that are not owned by the Crown. [4] In achieving this objective, Kiwirail also strives to achieve a number of non-commercial imperatives as outlined in its Statement of Corporate Intent, including:

- Safety outcomes (Zero harm)
- Customer engagement
- Operating performance standards

[4] State Owned Enterprises Act 1986

KiwiRail's commercial revenues are fairly diverse, but are dominated by its freight business as highlighted in Figure 2.

Figure 2: KiwiRail commercial revenue sources (2015)



3.1.2 Asset base and service provision

KiwiRail's asset base consists of approximately:

- 4,000 kms track (of which roughly 500km are currently mothballed)
- 1,656 bridges
- 18,000 ha of land managed
- 198 mainline locomotives
- 4,585 freight wagons
- 2 owned and 1 leased ferry
- 4,200 staff (approximate)

Each week, train control operations manage the movement of approximately:

- 900 freight trains
- 44 inter-city passenger trains
- 2,200 suburban passenger services in Wellington
- 2,000 suburban passenger services in Auckland[5]

3.2 Road-rail interface

Road and rail assets in New Zealand both largely sit within public sector balance sheets – rail assets with KiwiRail, and road assets predominantly with either the New Zealand Transport Agency or Local Authorities.

Funding for roading capital and operating expenditure is largely user-pays and predominantly comes from Fuel Excise Duty (FED), Road User Charges (RUC) and a range of smaller transport-related fees (e.g. vehicle registration). Some roading projects also receive funding from other sources such as council funded property rates or direct Crown investment.

Funding for rail capital and operating expenditure comes from a combination of commercial revenues (as noted in Figure 2) and subsidies (for both passenger and freight).

Despite the two networks effectively being owned by the state both road and rail are, in effect, in direct competition for customers in addition to competition the two networks can also provide different services for customers. In some circumstances these two networks work synergistically, however the general view is one of competition. While this competition can work to drive efficiencies in the New Zealand economy, it can also work to duplicate services and investment of capital.

In 2015 the Minister of Transport Hon. Simon Bridges asked KiwiRail and the NZ Transport Agency to work together to investigate a more integrated approach to land transport planning and investment. Improved planning and investment across road and rail was also identified as a recommendation of the Productivity Commission in its 2012 freight inquiry which was endorsed by the government[6].

Better integrating road and rail can be argued to improve the productivity of New Zealand's overall freight network specifically to increase the overall contribution of the two networks.

Understanding the public benefits of rail can be thought of a way of better understanding the direct Value of Rail and also the 'shadow subsidy' it provides the road network (as, for example, more rail wagons means less vehicles on the road and less need for roading investments).

[5] http://www.kiwirail.co.nz/about-us/who-we-are

6 http://www.productivity.govt.nz/inquiry-content/1508?stage=4

4. Detailed Findings

4.1 Congestion benefits

'Congestion benefits' is the calculation of the avoided road congestion costs expected to be encountered if all freight and passenger movements were transferred from rail to road. This is by far the largest contributor to the Value of Rail and represents an estimated 90.5% of all avoided costs calculated in this study. Total congestion cost imposed on the road network are made up of time delay costs as a result of extra freight on intercity and metro roads as well as extra light passenger vehicles on the Auckland and Wellington motorway networks. A large proportion of the congestion benefits arise from commuter rail with a significant contribution from intercity and metro freight movements. The freight metro congestion benefits has been calculated using the Auckland and Wellington transport models and the intercity congestion benefits have been calculated using NZTA data and the Economic Evaluation Manual.

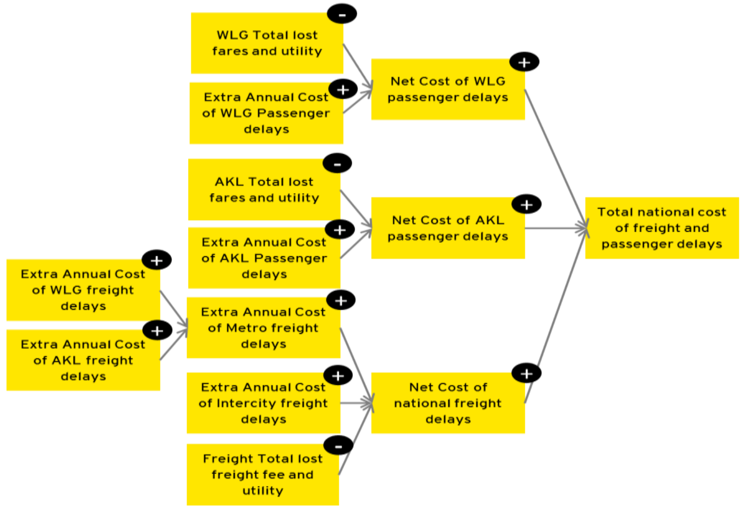
$1.39b to $1.34b

The total national cost of freight and passenger delays is a combination of net costs of delays in the Wellington and Auckland network as a result of passengers being transferred from road to rail and the net cost of national freight delays.

The net costs for each section as indicated in Figure 3 is calculated by subtracting existing rail delay costs (lost fares, freight charges and utility) from the extra costs that would be imposed on the network if freight and passengers were moved off rail and onto roads. The process for calculating each sub-calculation is detailed in the following sections, with final outputs from the model noted in Appendix A and C. In general terms many of the boxes in Figure 3 have computed the cost of delay time by multiplying the extra time delay experienced by all road users with an hourly rate from the NZTA Economic Evaluation Manual (EEM)[7].

Transportation model outputs from Auckland Transport and Greater Wellington Regional Council have been used in this analysis for estimating delay times caused by passengers and metro freight.

Figure 3: Total national cost of freight and passenger time delay calculation methodology



[7] NZTA Economic Evaluation Manual (2016)

4.1.1 Freight

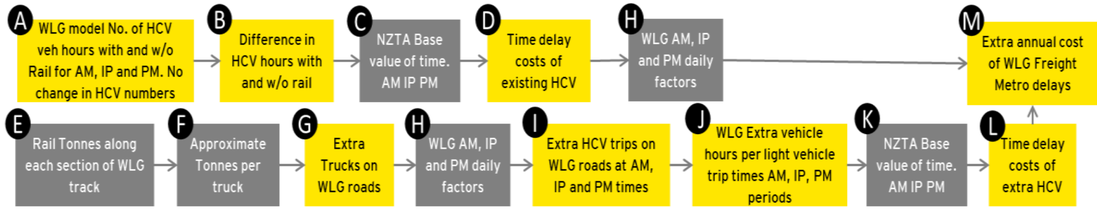
The total net amount of avoided time delay cost from transporting all freight by road instead of rail is estimated to be approximately $207.56m to $200.27m which represents 11.34m to 10.94m Heavy Commercial Vehicle (HCV) hours. This study has calculated this cost by considering the effects of freight within the metro areas Auckland and Wellington separately to the congestion effects on the intercity road network. By breaking down our calculations in this manner we can continue to use parts of the outputs from the Wellington and Auckland transport models to calculate the time delay cost, leaving only intercity time delay costs to be estimated based on calculations from the EEM. The value subtracted from the gross figure to calculate the net cost of freight delays is a whole of network figure (not metro or intercity) and represents existing lost utility and revenue on the rail network.

4.1.1.1 Metro

Gross value

The gross cost of the freight delay within the Auckland and Wellington metro centres is estimated to be $83.43m to $80.16m this represents an extra estimated 5.47m to 5.25m HCV hours within the two metro areas. This is significant and can potentially be attributed to large volumes (of all vehicle types) that move through existing arterial freight road routes. For example trucks move frequently between Ports of Auckland and Westfield (South Auckland) where they use an incredibly busy stretch of motorway that can reach over 100,000 (South bound only)[8] vehicles a day. Therefore adding extra HCV's can have a substantial impact on total vehicle travel times. The approach taken to calculate the gross time delay costs on the Wellington metro network is detailed in the below figure[9].

Figure 4: Gross metro freight time delay cost calculation methodology



Index	Title	Description
A	Number of HCV hours with and without rail for AM, IP and PM times	This has been calculate by proportioning the total vehicle hours between the HCV and light vehicles for the scenarios with and without rail (and uses the GWRC transport model average trip times).
B	Difference in HCV hours with and without rail	HCV hours with rail minus HCV hours without rail for each time period
C	NZTA. Base value of time for AM, IP and PM periods	Extracted from NZTA EEM (table A4.3)
D	Time delay cost of existing HCV	B multiplied by C
E	Rail tonnes along	Extracted from KiwiRail Data

8 NZTA AADT data (2015 recording at Gillies Ave section of SH1)

9 Wellington, Auckland, without and vehicles have been abbreviated to 'WLG', 'AKL', 'w/o' and 'veh' respectively. Grey boxes represent inputs and yellow boxes represent calculations.

	Wellington rail section of track	
F	Approximate tonnes per truck	12 tonnes based on NZTA factsheet.
G	Extra trucks on Wellington roads	E divided by F
H	Wellington AM, IP and PM daily factors	Extracted from Greater Wellington Regional Council model instructions
I	Extra HCV trips on Wellington roads at AM, IP and PM times.	Split G based on H's weightings
J	Extra light vehicle hours per extra light vehicle trip for Wellington at AM, IP and PM times	Extra light vehicle hours without rail divided extra light vehicle trips without rail. Note We could not compute the average extra HCV hours in a trip as the transport model did not output a change in HCV trip numbers and therefore light vehicles have been used as a conservative proxy
K	NZTA Base Value of time for AM, IP and PM periods	Refer to C
L	Time delay costs of extra HCV	This is the time delay from additional trucks (from rail). It is calculated by multiplying J and K then adding the figure up to a daily rate
M	Extra annual cost of Metro freight delays	Add L and D together and compute for an annual figure

This process is the same for calculating the freight delay cost in Auckland except the steps A, E and G change to Auckland specific sub calculations as detailed below.
A: Number of HCV hours with and without rail (for AM,IP and PM periods) is calculated by using the average vehicle journey time from the Wellington transport model outputs and the number of total HCV trips from the Auckland transport model outputs. This approach is conservative as it assumes extra travel times caused by extra freight in Auckland and Wellington will be the same per vehicle journey.
E: Rail tonnes are only needed for those in the Auckland rail network
G: Extra trucks on Auckland roads is again calculated by dividing E (above) by the average tonnes per truck.

The existing Metro freight rail delay cost is considered as whole with Intercity freight rail delay and therefore net figures will be presented in the following section.

4.1.1.2 Intercity

Gross value

The gross time delay cost from transferring intercity rail freight to roads is estimated to be $138.73m to $134.13 this represents an extra 5.96m to 5.77m HCV hours on the road network.

Delay times on intercity roads have been calculated using the EEM[10]. For these calculations we have assumed all intercity roads that rail freight is

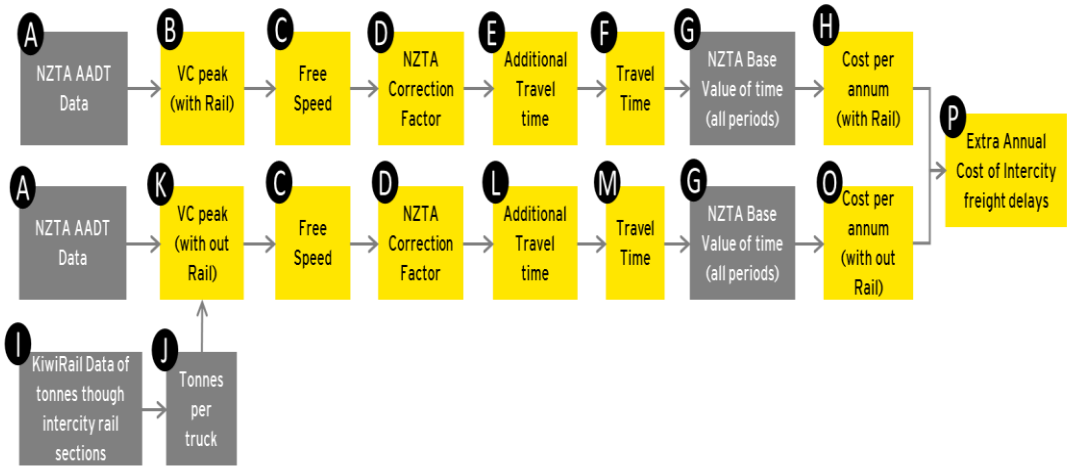
[10] NZTA Economic Evaluation Manual https://www.nzta.govt.nz/resources/economic-evaluation-manual

transferred to has the following characteristics

- 2 lane
- 'Rural Strategic'
- Level, rolling or mountainous road type
- 50% , 50% directional distribution,
- 20% no passing
- Free speed of 92km/h (design speed is below 100km/h)
- Basic Capacity of 2800pcu/h in both directions
- Conversion of rail sections to equivalent road sections has been computed using Google maps

This study uses NZTA AADT data to calculate the existing vehicle flow rate and also assumes that if freight was transferred to rail it will be distributed evenly throughout the day. These assumptions have been made to simplify the analysis and it is likely to dampen the congestion benefits as peak road loading has not been accounted for. To capture these effects a full transport model would be needed.
The following figure sets out the calculation methodology we have used which is primarily based upon the NZTA EEM methodologies (in particular section A3.18 and A3.11).

Figure 5: Intercity gross value of time delays



Index	Title	Description
A	NZTA AADT Data	Average Daily traffic from NZTA. In our calculations it has been divided by 24 hours in a day to obtain a vehicle per hour rate. Regional averages have been used for each rail equivalent section of road
B	VC peak (with rail)	VC has been calculated by dividing the existing veh per hour by a strategic rural road's stated capacity. This has been averaged across all roads and an estimate has been made to determine VC peak from this average
C	Free Speed	Calculated by using NZTA EEM table and assumes design speed is below 100km/h
D	NZTA Correction Factor	Extracted from NZTA EEM table based on Percent no passing and VC peak (B).
E	Additional travel	This is calculated by multiplying C and D

	time	
F	Travel time	Calculated by summing E and C
G	NZTA Base Value of time for all periods	Extracted from NZTA tables
H	Cost per annum with rail	Multiply F and G and sum for all road sections of road. Multiply this by the number of days in a year for per annum cost
I	KiwiRail Tonnage data by section of track	Received from KiwiRail
J	Tonnes per truck	12 tonnes based on NZTA truck mass and loading fact sheet
K	VC Peak without rail	This is calculated by adding new freight converted from rail freight (I divided by J) to the measured hourly traffic flow. This calculation is carried out for each equivalent road section, it is then averaged and an estimate is made from this as to what the new VC peak is
L	Additional Travel time	Old free speed C multiplied by new NZTA correction factor (based on % no passing and VC peak new) K
M	Travel Time	L plus C
O	Cost per annum without rail	M multiplied by G and then sum the calculated value for each section of road. Multiply this by the number of days in a year
P	Extra Annual Cost	Subtract H from O.

	of intercity freight delays

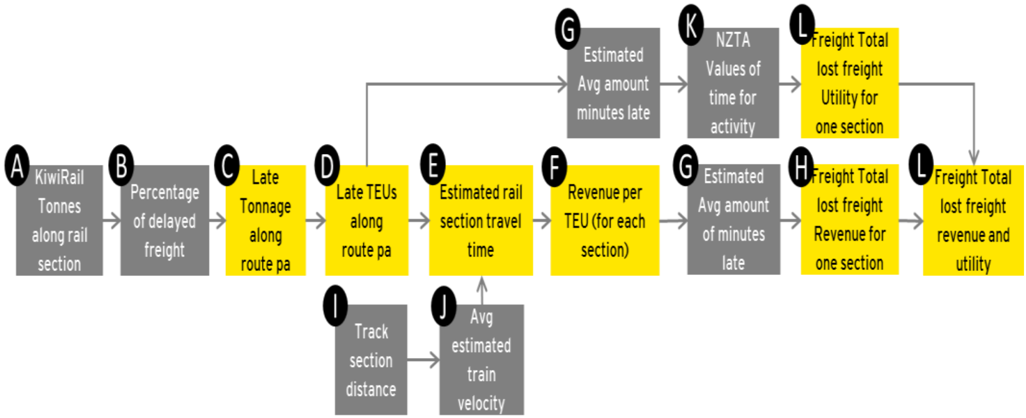
The main piece of sensitivity in this approach is caused by using an average peak VC across all road sections to calculate delay times as a result of extra freight. This produces a travel time per km which is constant across all intercity road sections.

Net value

Existing congesting costs on the freight rail lines has been subtracted from the gross intercity and metro freight value to produce a net figure. Existing rail congestion costs have been estimated at $14.59m to $14.03m this represents the lost utility and freight revenue from existing congestion on whole the rail network. It has been calculated by using the percentage of freight trains delayed, 79%[11] and the below methodology. The overall net value of freight time delay is $207.56m to $200.26m.

[11] KiwiRail Annual Report (2015)

Figure 6: Calculation methodology for existing congestion on rail network



Index	Title	Description
A	KiwiRail Tonnes along rail section	Data obtained from KiwiRail
B	Percentage of delayed freight	79% from KiwiRail Annual Report
C	Late Tonnage along section	Calculated by multiplying A and B
D	Late TEUs along section per annum	This is calculated by dividing C by the estimated average truck load which should be approximately equivalent to a single TEU
E	Estimated rail section travel time	I divided by J
F	Revenue per TEU (for each section)	Freight charge per TEU per km (for each section) multiplied by segment distance
G	Estimated average amount of minutes late	This has been estimated at 3min above the late tolerance level based on a calculated average rail section travel time of 42min.
H	Freight total lost revenue for one section	G divided by Journey time, E multiplied by F. This represents the cost of one late TEU along a section. This is then multiplied by D to calculate the total cost of late TEUs along the section
I	Track section distance	From KiwiRail Data
J	Avg estimated train velocity	Max speed of KiwiRail trains is 35-110km/h depending on curvature[12] so 60km/h was estimated
K	NZTA values of time for road activity	Extracted from NZTA EEM (table A4.1(b))
L	Freight total lost utility (for one section)	This is calculated by multiplying D, G and K together
M	Freight total lost revenue and utility	Sum revenue losses, H and utility losses, L for each section of track and then total all rail sections losses.

[12] National Rail System Standard : Engineering Interoperability Standards (2013)

Freight Calculation Limitations

- Congestions costs only include time delays and don't include reduced time reliability or incremental congestion costs, this makes our calculation conservative.
- This study has used a constant travel time per km (with and without rail) across the intercity road network by assuming an average type of road exists in all other place other than Wellington and Auckland. This does not take into account an individual section of roads characteristics. The 'average road' approach was used to simplify the analysis and it is expected that if a more detailed assessment were to be undertaken an in-depth traffic model would be needed to calculate intercity time delay costs.
- Existing capacity on the road sections other than (Auckland and Wellington) were calculated by averaging the NZTA AADT across the section of roads in each particular region.
- Delay time costs do not include flows of traffic on smaller roads not captured by Auckland or Wellington Transport models or other non-arterial rural roads.
- This study's analysis of time delays treats the time delay per HCV like that of a light vehicle when in reality HCV add more time delay to a road than light vehicles as they are slower and take up greater road space. This is conservative as it understates the time delay that would be placed onto the roads.
- This study's approach assumes that adding another HCV to metro road networks does not change the average light vehicle journey time when it could possibly increase the average vehicle time.
- It is likely that the congestion on the rail network which is subtracted from the gross figure is overstated as our calculations assume reliability is only related to congestion when this could be related to a range of other issues.
- Potential double handling costs and effects rail delays would have on downstream businesses has not been considered due to the natural difficulties in accurately estimating these effects. If it were to be included it would decrease freight rails benefit.

4.1.2 Passenger

The total net amount of avoided time delay costs from transporting passengers by road instead of rail has been estimated at $1.19b to $1.14b p.a. which equates to approximately 77.65m to 74.60m p.a. extra light vehicle hours in Auckland and Wellington.

This study estimates the time delay congestion cost imposed on the network within the metro areas of Auckland and Wellington where passenger services exist. The tourist passenger rail services (Northern Explorer, Coastal Pacific and TranzAlpine[13]) have been excluded from this analysis as we expect a large majority of these passengers would instead transfer by plane or would no longer travel through the area if rail was removed.

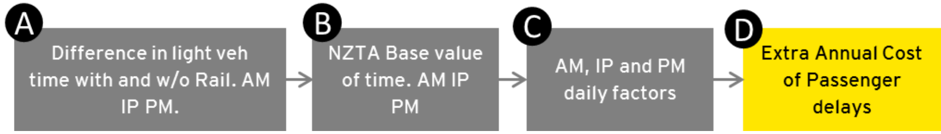
13 http://www.kiwirailscenic.co.nz/ (2016)

4.1.2.1 Wellington

This study has calculated the total net cost of time delays in the Wellington region from passengers as $303.74m to $291.83m. This represents approximately 19.89m to 19.11m extra light vehicle hours travelled on Wellington's road network. By using the Greater Wellington Regional Council's traffic model we were able to calculate time delay costs with some granularity as traffic flow data was segmented into AM, IP (Inter-Peak) and PM time periods.

<u>Gross value</u>
The gross congestion time delay cost has been calculated at $303.86m to $291.94m using the approach in below figure.

Figure 7: Wellington gross time delay cost methodology



Index	Title	Description
A	Difference in WLG vehicle time with and without rail, for AM, IP and PM	Difference in WLG model outputs light vehicle hours with and without rail for each period (AM, IP and PM). This excluded HCV hours.
B	NZTA Base value of time for AM, IP and PM periods	Extracted from EEM (table A4.3)
C	WLG AM, IP and PM factors	Supplied by Greater Wellington Regional Council
D	Extra Annual cost of WLG passenger delays	Calculated by multiplying A, B and C and then summing AM, IP and PM costs

<u>Net value</u>
To calculate the net costs of congestion, gross figures have had existing Wellington passenger rail delay costs subtracted from it. This represents the total lost fare and passenger utility from delayed trains at approximately $118,000. This is relatively small compared to the gross cost as only 1%[14] of Wellington passenger trains are late. Refer to Appendix E for this calculations methodology.

4.1.2.2 Auckland

The total gross time delay cost is estimated to be $863.43m to $848.78m and the amount subtracted from this which represents the delays in the existing Auckland passenger network is $0.77m leaving a net total of delay cost of $882.65m to $848.01m. This represents approximately an extra 57m to 55.5m pa extra light vehicle hours on Auckland roads.

This is the largest and most significant contributor to all Value of Rail benefits (or avoided costs). This comes as no surprise as sections of the Auckland motorway network are the most congested in New Zealand and adding extra traffic to key sections will cause delays felt across the entire

14 Metlink Performance Website (2016), https://www.metlink.org.nz/customer-services/public-transport-facts-and-figures/performance/

motorway network.

Gross value

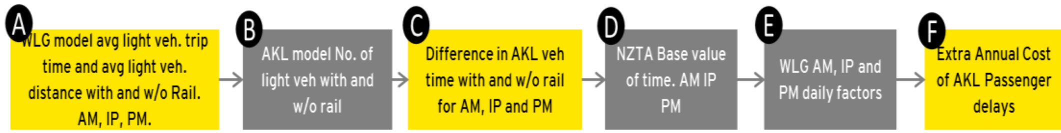
We have utilised AT transport modelling to understand gross passenger flows. A limitation is that its latest base year is 2013 when rail passenger numbers were approximately 13m pa trips (AT Statistics Report 2014)[15] and currently in 2016 they are approximately 16m[16] pa trips. We consider this approach conservative as less passengers in our analysis have been moved from rail to road than what would occur at a more recent date which has resulted in a lower avoided cost.

Another limitation of how we have used the Auckland model is that it only increased average trip time by 2.8%-1.9% and average trip length by 0.7% - 0.4% this is most likely due to the regional comparative static approach. We have therefore assumed that the Wellington transport model in this case appropriately portrays the increase in average vehicle trip length and average vehicle trip time. We consider this approach conservative given Wellington is smaller and will have a shorter average vehicle trip time and average vehicle trip distance.

The output we did use from the Auckland Transport model was the number of heavy and light vehicle trips with and without rail. This model output was generated based on the assumption that 75% of passengers moved to road with the remainder transferred to buses.

The gross time delay cost was calculated using the below methodology

Figure 8: Auckland gross time delay cost methodology



Index	Title	Description
A	Wellington model average vehicle trip time with and without rail for AM, IP and PM time periods.	Proportioned vehicle hours and vehicle trips into light and HCV using output based ratios. Average is calculated by dividing total light vehicle hours by the number of light vehicle trips in Wellington for each time period, with and without rail
B	Auckland model number of light vehicle trips, with and without rail	Output from AT (Auckland Transport) model
C	Difference in Auckland model light vehicle time with and without rail, for each time period (AM, IP, and PM)	Calculated by subtracting Auckland light vehicle hours with and without rail for each period (AM, IP and PM)
D	NZTA Base value of time AM, IP and PM	Extracted from EEM (table A4.3)
E	Wellington AM, IP and PM factors	Supplied by Greater Wellington Regional Council
F	Extra Annual cost of AKL passenger delays.	Calculated by multiplying B, C and D and then summing AM, IP and PM

15 AT Statistics Report 2014

16 AT Item 113 Monthly indicators Report (April 2016)

using E

Net Value

To calculate the net costs of the total time delay the existing Auckland passenger rail delay costs $773,000 has been subtracted from the gross figure. This existing passenger delay represents the total lost fares and passenger utility from delayed trains. This was relatively small compared to the gross cost as the percentage of Auckland passenger trains that are late is only 5%[18]. For this calculation's methodology refer to Appendix D.

Sensitivities have been calculated by increasing or decreasing input values by 2% these input values are Rail Tonnage data from KiwiRail, all Wellington traffic model outputs (total vehicle hours, total vehicle km, light vehicle trips and HCV trips) and Auckland Model outputs (light vehicle trips and HCV trips).

Passenger Calculation Limitation

- Congestions costs only includes time delays and does not include reduced reliability of journeys times or incremental cost of congestion which is when VC (Volume Capacity) is greater than 70%[17]. This study's calculations are conservative as the congestion cost presented does not include the other two factors.
- Light vehicle hours and light vehicle km's are based on AT and Wellington transport models that are slightly dated and will not have factored increased populations and changing user habits to public transport in particular the growth of passenger numbers for Auckland's rail network. This means gross passenger time delay figures could be underestimated thus representing a conservative approach taken for these calculations.
- Both transport models, model an average day rather than a typical week of traffic which could allow for weekend delays to be better accounted for in the time delay costings.
- The Greater Wellington Regional Council Traffic model assumes there is sufficient car parking capacity in the city to take extra light vehicle commuters and the Auckland Transport model assumes there is sufficient bus capacity to take its proportion of the rail patronage. These are conservative assumptions as congestion would be greater if they were not made.

17 NZTA Economic Evaluation Manual (2016)

18 AT rail performance results (2016). https://at.govt.nz/bus-train-ferry/train-services/rail-performance-results/

4.2 Maintenance benefits

The costs of maintaining the rail network are proportionally lower than the cost of maintaining the road network, particularly where freight is concerned. The maintenance cost saving of the rail network against the comparative static situation of no rail is estimated to be $65.95m to $63.37m this is the sum of net passenger and net freight rail benefits. Our study has calculated these benefits by using Road user Charges (RUC) to estimate marginal road maintenance costs, and comparing this with the maintenance cost of the rail network.

$65.95m to $63.37m

4.2.1 Freight

The total net amount of avoided maintenance cost from transporting all freight by road instead of rail is estimated to be approximately $80.39m to $77.23m. This figure was calculated by using RUC data to estimate the amount of additional road maintenance cost that would be incurred by shifting all existing rail freight movements to road, and subtracting existing rail maintenance costs to obtain net maintenance cost savings.

Gross Value

RUCs is intended to recover the costs of the damage that vehicles cause to NZ roads, and consequently can be used as a proxy for the dollar value of the marginal road damage caused by freight vehicle movements. Assuming that maintenance costs of rail freight movements are passed on to KiwiRail customers through freight prices, the difference between additional RUC charges paid if rail freight was moved to road and the current maintenance costs of the rail network represents an additional cost that would be incurred by the industry under the comparative static analysis.

RUC is paid by vehicles over 3.5 tonnes, which use diesel or other fuels not taxed at source.[19] Total annual RUC revenue reported by NZTA is broken into ‘heavy’ and ‘light’ categories. In order to calculate the average RUC per tonne-kilometre travelled by vehicles in the ‘heavy’ category, we used total heavy RUC revenues collected and divided this by total heavy vehicle NTK (also recorded by Ministry of Transport). As the vast majority of intercity freight movements (i.e. the type of road freight movements which would replace rail freight under the counterfactual) are currently made by diesel vehicles classified as ‘heavy’, we assume that this figure is representative of the marginal maintenance cost incurred from road freight movements.

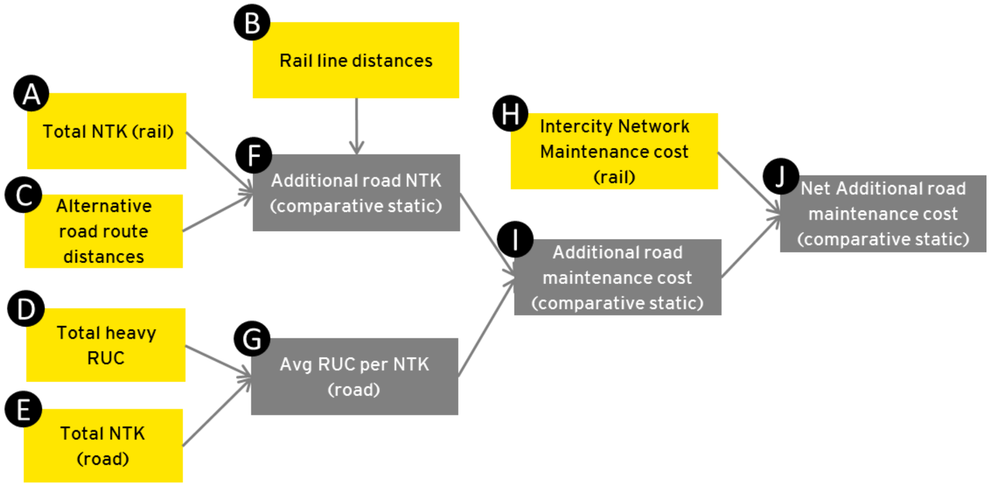
To estimate the total additional road maintenance cost incurred under the comparative static analysis, we multiplied this average cost-per-NTK by the total increase in road freight NTK required to deliver the current rail freight task, calculated using KiwiRail-supplied figures for total rail freight and shortest alternative road route distances, this resulted in gross figure of $170.4 m to 163.72m.

Net Values

We then arrived at a net figure for freight road maintenance of $65.95m to $63.37m by subtracting the intercity rail network maintenance $88.25m from the additional road maintenance costs $170.4m to $163.72m. The intercity rail network maintenance cost has been estimated based on the proportion of track that is located outside of rail passenger areas (Auckland and Wellington). Note that this results in a conservative net figure, as capital commitments (reported by KiwiRail) include investment in rolling stock, upgrades, plant and equipment etc as well as network renewals (the component analogous to RUC).

[19] https://www.nzta.govt.nz/vehicles/licensing-rego/road-user-charges/about-ruc/ (2016)

Figure 9: Calculation methodology for net freight maintenance cost



Index	Title	Description
A	Total NTK (rail)	Data obtained from KiwiRail
B	Rail line distances	Data obtained from KiwiRail
C	Alternative road route distances	Data obtained from Google maps
D	Total Heavy RUC	Data obtained from NZTA annual fleet statistics 2014
E	Total NTK (road)	Data obtained from MoT website: 'Charges for light petrol and diesel vehicles'
F	Additional NTK (counterfactual)	A multiplied by ratio of C and B
G	Average RUC per NTK (road)	D divided by E
H	Network maintenance cost (rail)	KiwiRail annual report 2014-15 (capital commitment) multiplied by proportion of track outside of Auckland and Wellington Region
I	Additional road maintenance cost (counterfactual)	F multiplied by G
J	Additional maintenance cost (net) under counterfactual	I subtract H

4.2.2 Passenger

Gross Value

The NZTA EEM states that road maintenance is only required for heavy vehicles and that light vehicles will cause negligible damage to the road[20]. Hence this study has not considered any maintenance costs that could arise by switching rail passengers to light vehicles. We have also conservatively assumed any extra load on the bus network will not surpass existing capacity resulting in no extra busses which would have caused extra damage to roads.

Net Value

The existing cost of passenger rail maintenance that would be saved has been estimated at $14.4m to $13.87m following a top down approach with total rail maintenance $102.4m[21] being apportioned over the metro regions (Auckland and Wellington) by total track lengths in each area in comparison to total national track length. This was the best approach given the lack of available data, however this does shift some freight induced maintenance within metro areas onto passenger rail maintenance as the methodology taken assumes passenger rail causes all the damage in the Auckland and Wellington regions. The net passenger maintenance benefits are -$14.4m to -$13.87m which is a result of assuming that light vehicle do not cause any road damage.

Sensitivities have been calculated by increasing or decreasing the following inputs by 2%, Rail Tonnage data from KiwiRail, total heavy RUC, KiwiRail capital investment, all Wellington traffic model outputs (total vehicle hours, total vehicle km, light vehicle trips and HCV trips) and Auckland Model outputs (light vehicle trips and HCV trips).

Maintenance Calculation Limitations

- Only total capital commitment figures for KiwiRail are available in the annual report, which include network upgrades, rolling stock and plant and equipment, in addition to network renewal. Consequently our savings estimate is considered conservative (the final figure would be higher if *only* network renewal-figures were provided by KiwiRail and substituted for totals, as these are analogous to RUC)
- Behavioral responses are not modelled – if the industry is paying a higher price for freight because they are covering more maintenance costs, this may impact freight quantities and have additional welfare impacts than those modelled here.
- Rail and trucking operating costs have not been considered by this study as there are many limitation in measuring and estimating them

20 NZTA EEM (2016)

21 Kiwi Rail Annual Report (2015)

4.3 Safety benefits

Another important benefit of rail is the safety benefits of moving both freight and passengers by rail instead of roads. The safety benefit of rail is estimated to be approximately $68.78m to $60.21m. This study has calculated benefits by transferring rail passengers and freight to light vehicles and trucks and applying factors from Ministry of Transport (MoT) to estimate the extra safety incident costs and subtracting the costs of existing safety incidents on the rail network. This represents the avoided safety cost of the rail network. The net safety benefit (avoided cost) of passenger rail is $8.28m to $3.97m and for freight rail it is $60.50m to $56.24m, even though the number of incidents is similar showing that transporting goods using heavy vehicles is more dangerous than rail.

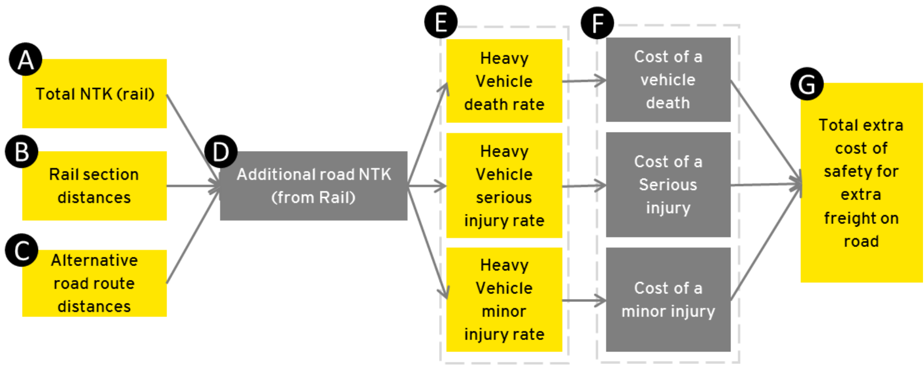
$68.78m to $60.21m

4.3.1 Freight

Gross value

The gross additional safety cost if all freight was transferred from road to rail is estimated to be $108.71m to $104.45m pa which represents approximately 186 to 179 additional safety incidents (deaths, serious injuries and minor injuries). The number of incidents for freight is less than that for passenger rail yet the freight induced safety cost is much higher because the proportion of incidents that are deaths or serious injuries are far greater for trucks than light vehicles. This value has been calculated using the following methodology.

Figure 10: Calculation methodology for the gross value of freight safety costs



Index	Title	Description
A	Total NTK (rail)	Data obtained from KiwiRail
B	Rail line distances	Data obtained from Kiwirail
C	Alternative road route distances	Data obtained from Google maps
C	Alternative road route distances	Data obtained from Google maps
D	Additional road NTKs	A divided by B for then multiplied by C each rail section. All sections are then summed together to form the total.
E	Heavy vehicle Death/ Injury rate.	These have been calculated by dividing average truck related deaths/injury by total truck NTK. Injury rates are split into minor and serious based on MoT proportions. Data is from MoT Fact sheets and MoT Excel Data sheets.
F	Cost of a death, serious injury and minor injury	Extracted from MoT 'Social cost of road crashes and injuries

		2015' report[22]
G	Total extra cost of safety for extra freight on road	This is calculated by multiplying D, E and F and summing death, serious and minor injury.

Net value

The existing safety cost across KiwiRail's network (including both passenger and freight services) is estimated to be $95.97m which represents 114 safety incidents (deaths, serious injuries or minor injuries). For existing rail freight safety costs this figure has again been apportioned based on occurrences this time for all regions excluding Auckland and Wellington. The net safety cost for freight rail is $60.50m to $56.24m.

The net safety cost for rail $68.78m to $60.21m has been calculated by adding the net safety cost for passenger rail and freight rail.

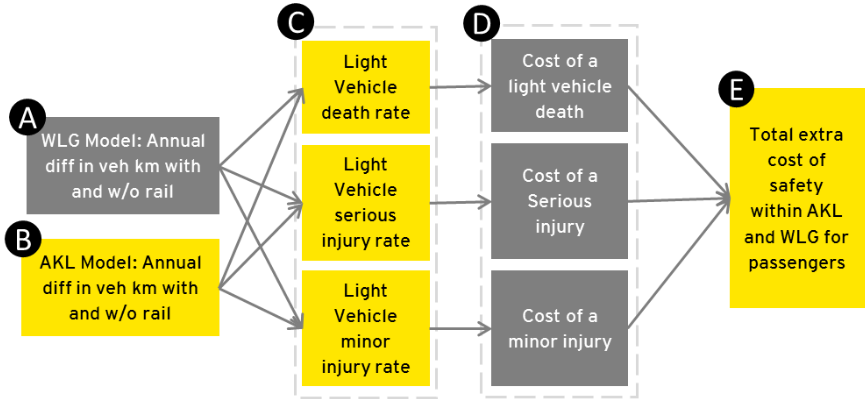
Sensitivities have been calculated by increasing or decreasing the following inputs by 2%, Rail Tonnage data from KiwiRail, light vehicle death and heavy vehicle deaths, all Wellington traffic model outputs (total vehicle hours, total vehicle km, light vehicle trips and HCV trips) and Auckland Model outputs (light vehicle trips and HCV trips).

4.3.2 Passenger

Gross value

The total gross safety costs arising from passengers within the metro networks being transferred from road to rail is estimated to be $56.04m to $51.73m and this represents approximately 211 to 194 additional safety incidents (deaths, serious injuries and minor injuries). This value has been calculated using the Ministry of Transport data, outputs from Auckland and Wellington Transportation models and the following methodology.

Figure 11: Gross value of passenger safety costs



Index	Title	Description
A	Annual difference in vehicle km travelled with and without rail	Difference is extracted from GWRC model output between annual vehicle km with and without rail. Or this figure could be computed from the daily vehicle km with and without rail
B	Annual difference in vehicle km travelled with and without rail	This is calculated by computing average light vehicle journey distance from GWRC model with and without rail (for each time period AM, IP and PM) This is then multiplied by the Auckland models output for number

[22] http://www.transport.govt.nz/assets/Uploads/Research/Documents/Social-cost-of-road-crashes-and-injuries-2015-update.pdf

		of light vehicle trips, with and without rail (for each time period) and the daily difference (with and without rail) in vehicle km is multiplied out to an annual rate.
C	Light vehicle death rate, serious injury rate and minor injury rate	Number of light vehicle deaths, serious injuries and minor injuries (in 2015) each divided by total vehicle km travelled. Data from MoT spreadsheets.
D	Cost of a death, serious injury and minor injury	Extracted from Ministry of Transport 'Social cost of road crashes and injuries 2015' report[23]
E	Total extra cost of safety within Auckland	Calculated by multiplying B, C and D and adding it to the result of

	and Wellington for passengers	multiplying A, C and D.

Net Value

The amount of existing rail safety incidents on the passenger section of the network has been subtracted from the gross figure to calculate the net safety value of passenger $8.28m to $3.97m. The total existing passenger rail safety costs calculated by multiplying the total rail safety incidents by MoT cost of deaths and injuries totaling $47.76m. These have been segmented (to passenger and freight) on the basis of rail occurrences[24] for each region. Rail occurrences are hazardous events that can lead to personal injury or death, using occurrences in this manner assumes safety incidents are proportional to occurrences. Occurrences in the Auckland and Wellington regions are assumed to be related to passenger rail safety incidents and occurrences in all other regions are related to freight rail. This approach marginally over allocates safety costs to passenger rail as it assumes freight trains cause no occurrences in Auckland and Wellington.

Safety Calculation Limitations

- Our calculations do not include analysis about increased driver aggression as a result of increased congestion which can lead to increased incidents as mentioned in the EEM
- Limitations in Auckland model have caused this study to use the Wellington models outputs to estimate total Auckland vehicle km travelled. Average journey travel distance with and without rail (for each time period) has been extracted from the Wellington model and used to calculate total Auckland vehicle km with and without rail (for each time period AM, IP and PM).
- These calculations assume the costs for each road death, serious and minor injury can be applied to the rail safety incidents.
- Only aggregate injury figures are available in the truck crash report, no breakdown of minor or serious injuries was provided so instead a graphical approximation was derived from the MoT Truck crashes Fact Sheet and used in calculations. Accuracy could be improved by obtaining a more precise breakdown between minor and serious injuries.
- Rail safety statistics did not break down the injuries into minor or major so an average cost per injury type has been used to calculate the costs of rail injuries.

[23] http://www.transport.govt.nz/assets/Uploads/Research/Documents/Social-cost-of-road-crashes-and-injuries-2015-update.pdf

[24] Ministry of Transport Rail Safety Statistics (2015)

4.4 Emissions benefits

The total emission cost figure represents avoided costs from transporting freight and passengers by rail and hence for this study it also represents the value of emission benefits. The estimated extra avoided cost (therefore benefits) of emissions created from moving Auckland and Wellington rail passengers and rail freight to road is $9.27m to $8.45m. This is a net figure and the emission savings arising from discontinued use of freight trains locomotives have been subtracted from the gross total. A modest proportion of the emission benefits is from the transfer of passenger services from road to rail with the largest amount of this net extra avoided cost arising from rail freight.

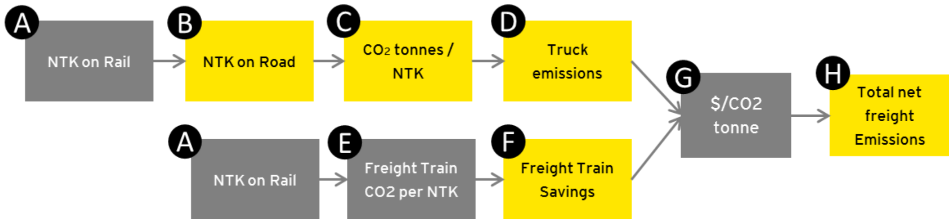
$9.33m to $8.49m

4.4.1 Freight

Gross and Net Value

The majority of the emission costs are generated from the transfer of freight to roads even when subtracting the savings from no longer operating diesel powered freight trains. Below sets our methodology for how we calculated the net emissions from freight.

Figure 12: Calculation methodology for gross and net value of freight emissions costs



Index	Title	Description
A	NTK on Rail	Extracted from KiwiRail's Data
B	NTK on Road	KiwiRail routes translated to equivalent road and roadi distance times by rail tonnes along route
C	CO_2 tonnes per NTK	Calculated by dividing Heavy Vehicle CO_2 emissions from MoT Fleet Statistics by B
D	Truck emissions	Calculated by multiplying C and D
E	Freight Train CO_2tonne/NTK	Calculated from the KiwiRails NTK figures and NZTA vehicle statistics
F	Freight Train Savings	Calculated by multiplying E and A
G	$ per CO_2 tonne	Spot price of carbon extracted from CommTrade website
H	Total net freight emissions	This is the addition of passenger and truck emissions as a result of moving them of rail and onto roads. Calculated by D multiplied by G minus F multiplied by G

The total cost of emissions arising from the extra freight is $9.14m to $8.44m with the existing CO_2 savings to be subtracted amounting to $2.87m to $2.65m. Hence the total net cost of freight emissions is $9.27m to $8.45m.

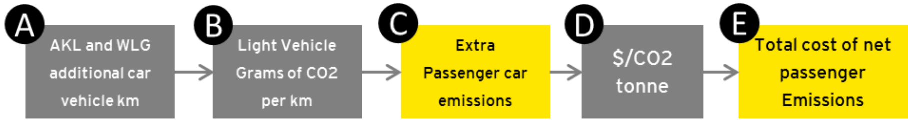
The freight cost savings are subtracted from the total extra emissions to calculate the net total emissions of 500,941 to 475,183 tonnes of CO_2. This figure is then multiplied by the current spot rate of carbon dioxide to calculate the total cost of emissions imposed on the economy.

4.4.2 Passenger

Gross and Net Value

Rail passenger emission costs make up a modest amount of the total emission costs. The total net emission costs from passengers is $3m to $2.67m pa ($2.29m to $2.03m from Auckland and $0.67m to $0.63m from Wellington). Below sets the methodology for our calculation.

Figure 13: Calculation methodology for gross and net passenger emission costs



Index	Title	Description
A	Passenger car vehicle km	No. of light veh trips from Wellington model output plus No. of light veh trips from Auckland model output multiplied by Average trip length from Wellington model.
B	Light vehicles CO_2g/km	Value extracted from Ministry of Transport Statistics Fuels vs CO_2 graphs
C	Extra passenger car emissions	This has been calculated by multiplying variables A and B.
D	$ per CO_2 tonne	Spot price of carbon extracted from CommTrade website
E	Total net cost of passenger emissions	Calculated by multiplying C and D

Both Auckland [25] and Wellington have electric powered trains and therefore have negligible emission savings to subtract from the extra emissions generated from the moving passengers from rail to roads.

Limitations of Emissions Calculations

- Limitations of this type of analysis is that the multiplier CO_2g/km are averages for heavy and light weight vehicle and this ignores some of the finer sub-classifications of vehicles and their differing emission rates within each sub-category.
- Passenger car vehicle km are based on AT and Wellington transport models that are slightly dated and will not have factored increased populations and changing user habits to public transport in particular the growth of passenger numbers for Auckland's rail network. This means the passenger emission figure could be understated.
- Extra emission from cars and HCV idling and spending longer in traffic have not been considered due to the complexity of modelling and as such this study's estimate of emissions costs is conservative
- No reliable measure was found to cost the other forms of emissions such as NO_x CO, hence this study conservatively estimated emission costs

[25] https://at.govt.nz/projects-roadworks/auckland-rail-upgrade/electric-trains/

4.5 Other benefits

There are many other forms of benefits that rail provides to New Zealand that cannot be as easily quantified. These other benefits will be analysed qualitatively and include:

- Connectivity Benefits
- Land Use and Value Uplifts
- Resilience Benefits

4.5.1 Connectivity Benefits

Rail provides connectivity benefits to the regional and national economy it serves. The main benefit being the ability to connect people to work, activities, and other people.

- People to Work: By connecting people more effectively to places of work more people have better access to more employment opportunities, reducing unemployment. It can also enable a more productive workforce by better linking, and therefore enabling matching, of employers to employees
- People to Activities: Effective rail public transport allows people to be better connected to activities such as sports, education, health and shopping which will result in an increased quality of life.
- People to other People: By providing access to effective rail public transport people can visit and connect more with other people such as friends and family. This will increase the quality of life for public transport users and provides independence benefits for elderly and young adult users.

These connectivity benefits are absorbed more heavily by those in lower socioeconomic groups[26] who sometimes cannot afford the upfront cost of a private vehicle or its operational expenses. These connectivity benefits are also more absorbed by those who cannot operate private vehicles such as the elderly or young adults.

In some instances connection benefits can also arise from business having greater access to freight lines resulting in better connections for imports and export routes.

By considering this study's comparative static scenario if rail no longer existed the connectivity benefits offered from public rail would no longer exist and hence it adds to the Value of Rail.

4.5.2 Land Use and Value Uplifts

It is a commonly witnessed phenomenon that residential land values in close proximity to train lines in particular trains stations experience an uplift in value as people value being close to public transport because it decreases travel times and increases connectivity[27] [28]. The lift in values can also positively influence the Councils total rates collected. It must also be noted that a value reduction can occur in certain circumstances for property near sensitive rail lines as noise/ vibration pollution and KiwiRail easement rights can decrease the value of properties especially residential properties in extremely close proximity to freight rail lines. But this

26 NZTA Public Transport information pack (2013)

27 Motu Economic and Public Policy Research : Anticipatory effects of rail upgrades (2010)

28 NZTA Public Transport Information pack (2013)

cumulative decrease in value will often be heavily outweighed by the total uplift in value mention previously.

In areas where land values have uplifted significantly it can become uneconomical to keep land in use as single story residential property and hence this can cause the land use to change to a more productive form.

This uplift phenomenon can also be experienced by industrial/ commercial properties as well but to a smaller degree in comparison to residential properties as not all business that rent/ own the property will be able to use the rail line productively and generate returns from it.

In consideration of the counterfactual scenario if rail no longer existed this value uplift and resulting rates increases would no longer exist hence this can be considered part of the Value of Rail.

4.5.3 Resilience Benefits

New Zealand's road network function is to provide a connectivity service to the public and for private enterprise to undertake commerce. When significant events take place that impact on the road network it can at times fail causing a loss of services and in extreme events a large loss of economic, social and cultural value.

Rail also provides the connectivity service that roads provide and hence adds a degree of redundancy to the overall transport system. So in the event of a challenge (such natural disaster, storm event or industrial disputes) imposing itself on the road network the wider transport system has the ability to continue functioning to some degree due to the existence of rail providing redundancy. This ensures that economic, social and cultural value loss is minimised by the continual operation of the transportation network. An example of rail providing resilience to the road network was in the event of the Christchurch earthquake where rail's ability to provide a fast supply of goods was utilised as roads leading into Christchurch and distributions centres within the city were damaged[29] and could not be used.

4.5.4 Port of Tauranga Case Study

The points in this case study highlight the often unaccounted benefit KiwiRail provides to private parties and it is at this interface where the public and private value of rail is blurred. However even though some benefits maybe captured by KiwiRail through their pricing, if rail were removed as proposed by this comparative static analysis the public value that flows from private value would no longer exist.

Further evidence of rails qualitative benefits is the symbiotic relationship between Port of Tauranga (POT) and KiwiRail. They have recognised that working together can create commercial synergies that can enhance the value of both companies.

POT is New Zealand's largest port, by volume[30] and a significant proportion of New Zealand's export volume passes through it. KiwiRail's

[29] MoT Refresh of Public Policy Paper for Rail (2013)
[30] Auckland Council: Ports of Auckland Future Study 2016

freight service benefits POT as without this service export products such as milk powder and logs produced in the Waikato-Bay of Plenty region would not be transported as efficiency or with as little strain on the area's road network. KiwiRail's general logistics solution for POT and further examples of the two organisations working hand-in-hand for mutual benefit include;

- POT report that increased efficiency on the rail connection between the Tauranga Container Terminal and the inland freight hub at MetroPort Auckland have resulted in a 24% increase in the volume of containers carried.[31] This indicates that POT see rail as a valuable tool and are invested in growing their use of rail freight to support their operations.
- POT establishing a rail link with Auckland Metro Port and the Port in Tauranga, keeping heavy loads off New Zealand's busiest roads. POT customers find using this service to send goods to Auckland via KiwiRails freight lines faster than shipping them from Tauranga to Auckland[26]
- KiwiRail works with POT across its logistics subsidiaries to deliver competitive and efficient results. The subsidiary Quality Marshalling operates the rail siding at the Tauranga Terminal, as well as operating at Rotorua, Kaingaroa and Napier. This shows that KiwiRail is willing to work with its freight partners to produce profitable outcomes for both parties[32].
- MetroPort Christchurch has been arranged in a manner that can accommodate rail, showing that POT is committed to using rail and that KiwiRail makes a valued contribution to its business.

In addition to the private (commercial) value of this relationship, by POT using KiwiRail's services this is likely to provide public value by reducing road congestion (especially in area of close proximity to the port), reduce safety costs, decrease road maintenance, provide emissions benefits and provide redundancy for how freight is moved to and from port facilities.

[31] Port of Tauranga Annual Report (2015)

[32] Port of Tauranga Annual Report (2015)

5. Conclusions

5.1 Findings and implications

This comparative static analysis for NZTA has found that passenger and freight rail both contribute significantly to the NZ economy. The total Value of Rail is estimated to be $1.54b to $1.47b, excluding all the qualitatively analysed benefits (connectivity, land use and value uplift, and resilience benefits) which would significantly increase the estimated value. The Value of Rail is split approximately77% from passenger rail services (in Wellington and Auckland) and 23% from freight rail services (throughout NZ). Across the benefit types, congestion benefits represent 91%, maintenance Benefits 4%, safety benefits 4% and emission benefits 1% of the total estimated Value of Rail. These results are displayed diagrammatically in Appendix C.

These figures have been calculated using a comparative static which compares scenarios with and without rail. Hence the behavioural changes that occur as a result of removing rail have not been considered. Other limitations have been worked around by using conservative assumptions, including:

- Using Wellington model outputs to approximate Auckland vehicle travel times and distances with and without rail.
- Approximating delays within Metro areas caused by HCV with delays caused by light vehicles.
- Using a constant VC peak with and without rail for a ‘generic’ intercity road.
- Conservatively using an overestimated rail maintenance cost saving which includes ‘above the line’ maintenance figures.

The quantitative and qualitative analysis of the estimated Value of Rail figure indicates that by following a conservative approach rail’s value is substantive. It also shows that KiwiRail’s freight service provides significant economic value and that it is an economic enabler to the many regions it serves.

An implication of these results is that the value of passenger rail is highly likely to exceed the support it receives from government and council subsidies, indicating that it provides good value for money. The implications of the value of freight rail findings is that its value is also likely to exceed its government support, hence representing good value for money. However, more analysis should be undertaken to confirm this.

The results generated can only be used for valuing the whole rail network and while (as a whole) the net benefit is significant, individual corridors may not provide a net benefit and further analysis would be needed when considering mothballing or closing individual rail corridors. This analysis is also only for one year after the transfer of rail load to the road network and does not predict or value rail past this point.

5.2 Why a conservative approach has been taken

A conservative approach has been taken with this study’s calculations and qualitative analysis because this is intended to be a high level estimate that will give an indication as to the size and magnitude of the economic benefits and costs, and is not intended to be a precise final value. The conservative approach also has the ability to stand up to further scrutiny and offer itself as a starting point from which more detailed calculations can build on in the future.

5.3 Next Steps

We recognise that the calculated Value of Rail can be further refined with the use of more detailed inputs and methodologies, which will provide a basis to remove some of the overly conservative assumptions. Next steps that can be taken to improve the analysis include:

- Detailed transport modelling of HCV in Metro areas and a bespoke traffic model of Inter-city roads.
- More refined usage of the Auckland Transport model.
- Updated passenger volumes in both Auckland Transport and Greater Wellington Regional Council transport models.
- Analyse behavioural, second order impacts from not having rail with the aid of updated transport models. This means models could incorporate peak load spreading and other behaviour related features.
- Break down of above- and below-the-rail line maintenance costs.
- Quantitative analysis of property Value Uplifts and Resilience.

Appendix A Model Outputs Tables

Summary Costing ($/pa) ***High Sensitivity***				
		Passenger	Freight	Total
Net Time Delay Benefits	<<$pa>>	$ 1,186,395,369	$ 207,560,270	$ 1,393,955,639
Net Emission Benefits	<<$pa>>	$ 3,003,691	$ 6,270,225	$ 9,273,916
Net Safety Benefits	<<$pa>>	$ 8,277,747	$ 60,501,307	$ 68,779,054
Net Maintenance Benefits	<<$pa>>	-$ 14,432,812	$ 80,385,436	$ 65,952,624
Total Net Comparative Static Benefits	<<$pa>>	$ 1,183,243,995	$ 354,717,238	$ 1,537,961,233

Summary Costing ($/pa) **Low Sensitivity**				
		Passenger	Freight	Total
Net Time Delay Benefits	<<$pa>>	$ 1,139,835,130	$ 200,266,912	$ 1,340,102,041
Net Emission Benefits	<<$pa>>	$ 2,663,992	$ 5,788,085	$ 8,452,078
Net Safety Benefits	<<$pa>>	$ 3,968,640	$ 56,238,165	$ 60,206,805
Net Maintenance Benefits	<<$pa>>	-$ 13,866,820	$ 77,233,066	$ 63,366,246
Total Net Comparative Static Benefits	<<$pa>>	$ 1,132,600,942	$ 339,526,229	$ 1,472,127,170

Summary Values ***High Sensitivity***		
Net Time Delay	<<ALLveh.hours>>	88,994,167
Net Emmission	<<tonnes of CO2>>	500,941
Net Deaths, Injuries and Accidents	<<Deaths, Injuries, Accidents>>	283

Summary Values **Low Sensitivity**		
Net Time Delay	<<ALLveh.hours>>	85,538,723
Net Emmission	<<tonnes of CO2>>	475,183
Net Deaths, Injuries and Accidents	<<Deaths, Injuries, Accidents>>	259

Time Delay Costing	*High Sensitivity*			
Passenger Time Induced Delays		New Road Delay (counterfactual)	Existing Rail Delays	Net Amount
Auckland Passenger Time Delays	<<$pa>>	$ 883,426,501	$ 773,011	$ 882,653,490
Wellington Passenger Time Delays	<<$pa>>	$ 303,859,613	$ 117,734	$ 303,741,879
Total Passenger Time Delays	<<$pa>>	$ 1,187,286,114	$ 890,745	$ 1,186,395,369
Freight Time Induced Delays				
Intercity Delays	<<$pa>>	$ 138,728,616.52	$ -	$ 138,728,616.52
Freight Delays within AKL and WLG	<<$pa>>	$ 83,429,891.56	$ -	$ 83,429,891.56
Total Freight Time Delays	<<$pa>>	$ 222,158,508.07	$ 14,598,238.12	$ 207,560,269.95
Total Time Induced Delay Cost	<<$pa>>	$ 1,409,444,622.53	$ 15,488,983.15	$ 1,393,955,639.37

Time Delay Costing	Low Sensitivity			
Passenger Time Induced Delays		New Road Delay (counterfactual)	Existing Rail Delays	Net Amount
Auckland Passenger Time Delays	<<$pa>>	$ 848,782,325	$ 773,011	$ 848,009,314
Wellington Passenger Time Delays	<<$pa>>	$ 291,943,550	$ 117,734	$ 291,825,816
Total Passenger Time Delays	<<$pa>>	$ 1,140,725,875	$ 890,745	$ 1,139,835,130
Freight Time Induced Delays				
Intercity Delays	<<$pa>>	$ 134,134,626.20	$ -	$ 134,134,626.20
Freight Delays within AKL and WLG	<<$pa>>	$ 80,158,131.10	$ -	$ 80,158,131.10
Total Freight Time Delays	<<$pa>>	$ 214,292,757.30	$ 14,025,845.56	$ 200,266,911.74
Total Time Induced Delay Cost	<<$pa>>	$ 1,355,018,631.97	$ 14,916,590.60	$ 1,340,102,041.37

Time Delay veh.hours	*High Sensitivity*			
Passenger Time Induced Delays		New Road Delay (counterfactual)	Existing Rail Delay	Net Amount
Auckland Passenger Time Delays	<<veh.hours/pa >>	57,812,015	40,833	57,771,181
Wellington Passenger Time Delays	<<veh.hours/pa >>	19,885,826	7,076	19,878,750
Total Passenger time delays	<<veh.hours/pa >>	77,697,841	47,909	77,649,932
Freight Time Induced Delays				
Intercity Freight Delays	<<veh.hours/pa >>	5,966,822	-	
Freight Delays within AKL and WLG	<<veh.hours/pa >>	5,467,269	-	
Total Freight time delays	<<veh.hours/pa >>	11,434,091	89,855	11,344,236
Total Time Induced Delay Cost	<<veh.hours >>	89,131,932	137,764	88,994,167

Time Delay veh.hours	Low Sensitivity			
Passenger Time Induced Delays		New Road Delay (counterfactual)	Existing Rail Delay	Net Amount
Auckland Passenger Time Delays	<<veh.hours/pa >>	55,544,877	40,833	55,504,044
Wellington Passenger Time Delays	<<veh.hours/pa >>	19,105,990	7,076	19,098,914
Total Passenger time delays	<<veh.hours/pa >>	74,650,867	47,909	74,602,957
Freight Time Induced Delays				
Intercity Freight Delays	<<veh.hours/pa >>	5,769,231	-	
Freight Delays within AKL and WLG	<<veh.hours/pa >>	5,252,866	-	
Total Freight time delays	<<veh.hours/pa >>	11,022,097	86,332	10,935,765
Total Time Induced Delay Cost	<<veh.hours >>	85,672,964	134,241	85,538,723

CO2 Emission Costing *High Sensitivity*				
Passenger Induced Emission Costs		New Road Emission (counterfactual)	Existing Rail Emissions	Net Amount
Auckland Passenger Emission Costs	<<$pa>>	$ 2,292,272.36	$ -	$ 2,292,272.36
Wellington Passenger Emission Costs	<<$pa>>	$ 711,418.53	$ -	$ 711,418.53
Total Passenger Emission costs	<<$pa>>	$ 3,003,690.88	$ -	$ 3,003,690.88
Total Freight Emission Costs	<<$pa>>	$ 9,142,955.45	$ 2,872,730.58	$ 6,270,224.87
Total Net Emssions Cost	<<$pa>>	$ 12,146,646.34	$ 2,872,730.58	$ 9,273,915.76

CO2 Emission Costing *Low Sensitivity*				
Passenger Induced Emission Costs		New Road Emission (counterfactual)	Existing Rail Emissions	Net Amount
Auckland Passenger Emission Costs	<<$pa>>	$ 2,033,030.66	$ -	$ 2,033,030.66
Wellington Passenger Emission Costs	<<$pa>>	$ 630,961.53	$ -	$ 630,961.53
Total Passenger Emission costs	<<$pa>>	$ 2,663,992.20	$ -	$ 2,663,992.20
Total Freight Emission Costs	<<$pa>>	$ 8,439,921.59	$ 2,651,836.26	$ 5,788,085.32
Total Net Emsions Cost	<<$pa>>	$ 11,103,913.78	$ 2,651,836.26	$ 8,452,077.52

CO2 Emission *High Sensitivity*				
Passenger Induced Emission		New Road Emission (counterfactual)	Existing Rail Emissions	Net Amount
Auckland Passenger Emission	<<CO2 tonnes/pa>>	123,820	-	123,820
Wellington Passenger Emission	<<CO2 tonne/pa>>	38,428	-	38,428
Total Passenger Emission	<<CO2 tonne/pa>>	162,248	-	162,248
Total Freight Emission	<<CO2 tonnes/pa>>	493,867	155,174	338,693
Total Net Emsions Cost	<<CO2 tonnes/pa>>	656,114	155,174	500,941

CO2 Emission *Low Sensitivity*				
Passenger Induced Emission		New Road Emission (counterfactual)	Existing Rail Emissions	Net Amount
Auckland Passenger Emission	<<CO2 tonnes/pa>>	114,299	-	114,299
Wellington Passenger Emission	<<CO2 tonne/pa>>	35,473	-	35,473
Total Passenger Emission	<<CO2 tonne/pa>>	149,772	-	149,772
Total Freight Emission	<<CO2 tonnes/pa>>	474,499	149,088	325,411
Total Net Emsions Cost	<<CO2 tonnes/pa>>	624,271	149,088	475,183

Safety and Accident Costing *High Sensitivity*				
Passenger Induced Safety Costs		New Road Safety Cost (Counteractual)	Existing Rail Safety Cost	Net Amount
Auckland Passenger Safety Costs	<<$pa>>	$ 42,766,989	$ 25,084,457	$ 17,682,531
Wellington Passenger Safety Costs	<<$pa>>	$ 13,272,955	$ 22,677,739	-$ 9,404,784
Total Passenger Safety costs	<<$pa>>	$ 56,039,944	$ 47,762,196	$ 8,277,747
Total Freight Safety Costs	<<$pa>>	$ 108,710,111	$ 48,208,804	$ 60,501,307
Total Net Safety Cost	<<$pa>>	$ 164,750,054	$ 95,971,000	$ 68,779,054

Safety and Accident Costing *Low Sensitivity*				
Passenger Induced Safety Costs		New Road Safety Cost (Counteractual)	Existing Rail Safety Cost	Net Amount
Auckland Passenger Safety Costs	<<$pa>>	$ 39,478,485	$ 25,084,457	$ 14,394,028
Wellington Passenger Safety Costs	<<$pa>>	$ 12,252,351	$ 22,677,739	-$ 10,425,388
Total Passenger Safety costs	<<$pa>>	$ 51,730,836	$ 47,762,196	$ 3,968,640
Total Freight Safety Costs	<<$pa>>	$ 104,446,969	$ 48,208,804	$ 56,238,165
Total Net Safety Cost	<<$pa>>	$ 156,177,805	$ 95,971,000	$ 60,206,805

Safety and Accident Amounts *High Sensitivity*				
Passenger Induced Death, Injury & Accident		New Road Incidents (counterfactual)	Existing Rail Incidents	Net Amount
Auckland Passenger Death, Injury and Accident	<<Incidents/pa>>	161	30	131
Wellington Passenger Death, Injury and Accident	<<Incidents/pa>>	50	27	23
Total Passenger Death Injury and Accident	<<Incidents/pa>>	211	57	154
Total Freight Death Injury & Accident	<<Incidents/pa>>	186	57	129
Total Net Safety Incidents	<<Incidents/pa>>	396.4626491	113.6	282.8626491

Safety and Accident Amounts *Low Sensitivity*				
Passenger Induced Death, Injury & Accident		New Road Incidents (counterfactual)	Existing Rail Incidents	Net Amount
Auckland Passenger Death, Injury and Accident	<<Incidents/pa>>	148	30	119
Wellington Passenger Death, Injury and Accident	<<Incidents/pa>>	46	27	19
Total Passenger Death Injury and Accident	<<Incidents/pa>>	194	57	138
Total Freight Death Injury & Accident	<<Incidents/pa>>	179	57	122
Total Net Safety Incidents	<<Incidents/pa>>	372.9806492	113.6	259.3806492

Maintenance Costing *High Sensitivity*				
Passenger Induced Maintenance Costs		New Road Maintenance Cost(Counteractual)	Existing Rail Maintenance Cost	Net Amount
Auckland Passenger Maintenance Costs	<<$pa>>	$ -	$ 5,604,076	-$ 5,604,076
Wellington Passenger Maintenance Costs	<<$pa>>	$ -	$ 8,828,736	-$ 8,828,736
Total Passenger Maintenance Costs	<<$pa>>	$ -	$ 14,432,812	-$ 14,432,812
Total Freight Maintenance Costs	<<$pa>>	$ 170,400,624	$ 90,015,188	$ 80,385,436
Total Net Maintenance Cost	**<<$pa>>**	**$ 170,400,624**	**$ 104,448,000**	**$ 65,952,624**

Maintenance Costing *Low Sensitivity*				
Passenger Induced Maintenance Costs		New Road Maintenance Cost(Counteractual)	Existing Rail Maintenance Cost	Net Amount
Auckland Passenger Maintenance Costs	<<$pa>>	$ -	$ 5,384,309	-$ 5,384,309
Wellington Passenger Maintenance Costs	<<$pa>>	$ -	$ 8,482,511	-$ 8,482,511
Total Passenger Maintenance Costs	<<$pa>>	$ -	$ 13,866,820	-$ 13,866,820
Total Freight Maintenance Costs	<<$pa>>	$ 163,718,246	$ 86,485,180	$ 77,233,066
Total Net Maintenance Cost	**<<$pa>>**	**$ 163,718,246**	**$ 100,352,000**	**$ 63,366,246**

Appendix B References, Sources and Data Limitations

No.	Name	Reference	Date accessed	Limitations
1	State Owned Enterprise	http://www.legislation.govt.nz/act/public/1986/0124/latest/DLM97377.html	July 2016	N/A
2	Above the line and Below the line definition	KiwiRail Annual Report FY2015	July 2016	▶ Only an indicative list of above and below the rail line assets and costs
3	NZTA Vehicle dimensions and mass fact sheet (2013)	http://www.nzta.govt.nz/resources/factsheets/13	July 2016	▶ No average value stated so estimates have been based on stated load values
4	State Owned Entities Act	http://www.legislation.govt.nz/act/public/1986/0124/latest/DLM97377.html	July 2016	N/A
5	KiwiRail About Us	http://www.kiwirail.co.nz/about-us/who-we-are	July 2016	N/A
6	Productivity Commissions International Freight report (2012)	http://www.productivity.govt.nz/inquiry-content/1508?stage=4	September 2016	N/A
7	NZTA EEM (2016)	https://www.nzta.govt.nz/resources/economic-evaluation-manual	June 2016	N/A
8	NZTA AADT (2015) Data	https://www.nzta.govt.nz/resources/state-highway-traffic-volumes/	July 2016	Used to calculate vehicle hourly flow rate after removing on and off ramp data. Vehicle per hour was calculated by dividing the AADT figure by the number of hours in a day.
9	Abbreviations			
10	NZTA Economic Evaluation Manual	https://www.nzta.govt.nz/resources/economic-evaluation-manual	June 2016	N/A
11	KiwiRail Annual Report (2015)	http://www.kiwirail.co.nz/media/publications	June 2016	N/A

No.	Name	Reference	Date accessed	Limitations
12	National Rail System Standard : Engineering Interoperability Standards (2013)	http://www.kiwirail.co.nz/in-the-community/accessing-the-corridor/nrss-policies.html	August 2016	No exact average number was given however Peter Reidy did state during the Trans-Tasman Business Circle Briefing that the max train speed on NZ tracks was 80km/h
13	Kiwi Rail Scenic journey names	http://www.kiwirailscenic.co.nz/	August 2016	N/A
14	Metlink Performance Website (2016),	https://www.metlink.org.nz/customer-services/public-transport-facts-and-figures/performance/	August 2016	▶ Did not break down performance per line so a whole of network average was taken
15	AT Statistics Report 2014	Auckland Transport Statistics Report 2014	August 2016	N/A
16	AT Item 113 Monthly indicators Report (April 2016)	https://at.govt.nz/about-us/our-role-organisation/meetings-minutes/	August 2016	N/A
17	AT rail performance results (2016)	https://at.govt.nz/bus-train-ferry/train-services/rail-performance-results/	August 2016	N/A
18	NZTA EEM (2016)	https://www.nzta.govt.nz/resources/economic-evaluation-manual	June 2016	N/A
19	About Road User Charges	https://www.nzta.govt.nz/vehicles/licensing-rego/road-user-charges/about-ruc/	July 2016	N/A
20	NZTA EEM (2016)	https://www.nzta.govt.nz/resources/economic-evaluation-manual	June 2016	▶ Used the EEM for a typical road section rather than a whole road network to approximate the increase in time delays
21	KiwiRail Annual Report (2015)	http://www.kiwirail.co.nz/media/publications	June 2016	N/A

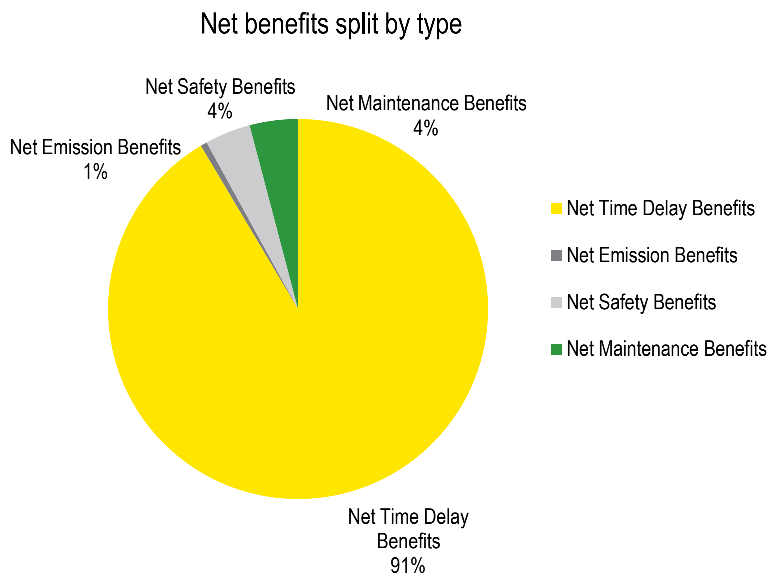
No.	Name	Reference	Date accessed	Limitations
22	Ministry of transport - Social cost of road crashes and injuries 2015 report	http://www.transport.govt.nz/assets/Uploads/Research/Documents/Social-cost-of-road-crashes-and-injuries-2015-update.pdf	July 2016	▶ Valuations are specifically for road, and not available for rail. Accuracy could be improved by obtaining separate valuations for rail deaths and injuries.
23	Ministry of transport - Social cost of road crashes and injuries 2015 report	http://www.transport.govt.nz/assets/Uploads/Research/Documents/Social-cost-of-road-crashes-and-injuries-2015-update.pdf	July 2016	▶ Valuations are specifically for road, and not available for rail. Accuracy could be improved by obtaining separate valuations for rail deaths and injuries.
24	Ministry of Transport Rail Safety Statistics (2015)	http://www.transport.govt.nz/assets/Uploads/Research/Documents/Rail-Safety-Statistics-December2014.pdf	July 2016	▶ Only aggregate injury figures available in safety statistics, so an average of minor and severe injury valuations was used to calculate total injury costs. Accuracy could be improved by obtaining a breakdown between minor and serious injuries. ▶ No break down for passenger of freight train induced injury/ death therefore we had to break passenger and freight up based on 'Occurrences' in each region
25	Electric trains pollution information	https://at.govt.nz/projects-roadworks/auckland-rail-upgrade/electric-trains/	August 2016	▶ No comparative information could be found about Wellington's trains therefore we have based their emissions on the Auckland Transport trains emissions.
26	NZTA Public Transport Information Pack (2013)	https://www.nzta.govt.nz/resources/public-transport-information-pack/	August 2016	N/A
27	Motu Economic and Public Policy Research : Anticipatory effects of rail upgrades (2010)	http://nzresearch.org.nz/records?direction=desc&i%5Bcreator%5D=Arthur+Grimes&i%5Byear%5D=2010&locale=en&recordset=all&sort=syndication_date	August 2016	N/A
28	NZTA Public Transport information pack (2013)	https://www.nzta.govt.nz/resources/public-transport-information-pack/	August 2016	N/A
29	Ministry of Transport Refresh of Public Policy Paper for Rail (2013)	Received via email from KiwiRail	July 2016	N/A

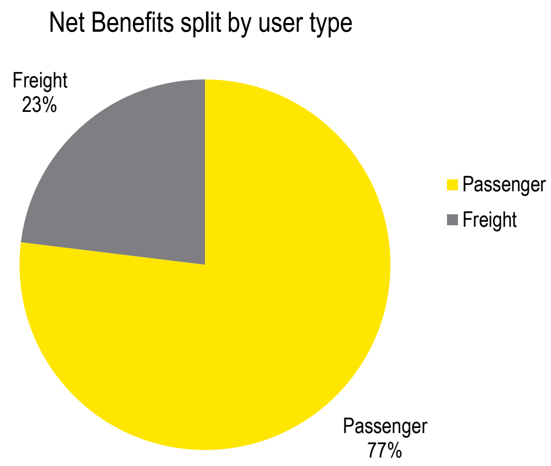
No.	Name	Reference	Date accessed	Limitations
30	Auckland Council: Ports of Auckland Future Study (2016)	http://www.portfuturestudy.co.nz/scope/	July 2016	N/A
31	Port of Tauranga Annual Report (2015)	http://www.port-tauranga.co.nz/Investors/Financial-Information/Download-Annual-Report/	August 2016	N/A
32	Port of Tauranga Annual Report (2015)	http://www.port-tauranga.co.nz/Investors/Financial-Information/Download-Annual-Report/	August 2016	N/A
Model	Rail on-time performance - Wellington	https://www.metlink.org.nz/customer-services/public-transport-facts-and-figures/performance/	August 2016	▶ This is a whole network figure and could possibly be different for different sections of track and lead to greater accuracy
Model	Rail on-time performance Auckland	https://at.govt.nz/bus-train-ferry/train-services/rail-performance-results/	August 2016	▶
Model	Ministry of Transport Data Heavy vehicle data (emissions, total NTKs)	NZTA 2014 Annual fleet statistics, sheets 1.10, 11.1, 11.2 http://www.transport.govt.nz/research/newzealandvehiclefleetstatistics/	22/07/2016	▶ Approach uses total emissions to calculate average per NTK. Accuracy could be improved by investigating specific truck types that would be likely to pick up the additional road freight task under the counterfactual and associated emission rates.
Model	Ministry of Transport Data Light vehicle data			▶

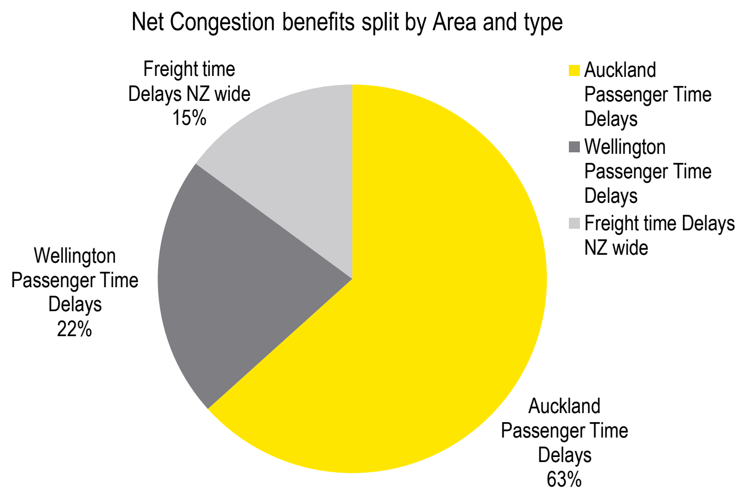
No.	Name	Reference	Date accessed	Limitations
Model	Ministry of transport road freight safety data	MoT 2015 truck crash facts http://www.transport.govt.nz/assets/Uploads/Research/Documents/Trucks-2015.pdf	22/07/2016	▶ Only aggregate injury figures available in truck crash report, so the split between serious and minor injuries had to be calculated using graphical approximations. Accuracy could be improved by obtaining a breakdown between minor and serious injuries. ▶ Data includes all deaths/injuries even when truck was not at fault. Unclear whether these can be attributed to truck presence.
Model	KiwiRail NZ rail emission rates	KiwiRail sustainability report 2014 http://www.kiwirail.co.nz/uploads/Publications/KiwiRail%20Sustainability%20Report%202014.pdf	22/07/2016	▶ Rail emissions rate reported is generic. May be in reality that there are different emissions rates for different services and lines.
Model	Commtrade NZ carbon price	Commtrade Carbon https://www.commtrade.co.nz/	22/07/2016	▶ Spot price for carbon is trending sharply upwards, increasing more than 200% in the last two years, indicating that the market price may yet be accurately reflecting the true value of carbon emissions.
Model	NZTA RUC revenue	Charges for light petrol and diesel vehicles http://www.transport.govt.nz/land/roadusercharges/light-petrol-vs-diesel	22/07/2016	▶ Approach uses total RUC revenue to calculate average per NTK. Accuracy could be improved by investigating specific truck types (and associated RUC rates) that would be likely to pick up the additional road freight task under the counterfactual.
Model	KiwiRail capital investment	Kiwirail annual report 2014-15 http://www.kiwirail.co.nz/uploads/Publications/KiwiRail%20Annual%20Report%202014-2015.pdf	22/07/2016	▶ Only total capital commitment figures for KiwiRail are available in the annual report, which include network upgrades, rolling stock and plant and equipment, in addition to network renewal. Accuracy could be improved by obtaining figures for network renewal only as this is comparable to the maintenance cost captured by RUC.
Model	Equivalent road route distances	Google maps https://www.google.co.nz/maps	22/07/2016	▶ Rail distance used for destinations not registered in google maps ▶ Alternative routes are shortest rail distances between stations, not actual road freight routes. Accuracy could be improved by researching common truck freight routes.
Model	KiwiRail Commercial Review (2014)	http://www.kiwirail.co.nz/media/publications.html	August 2016	N/A

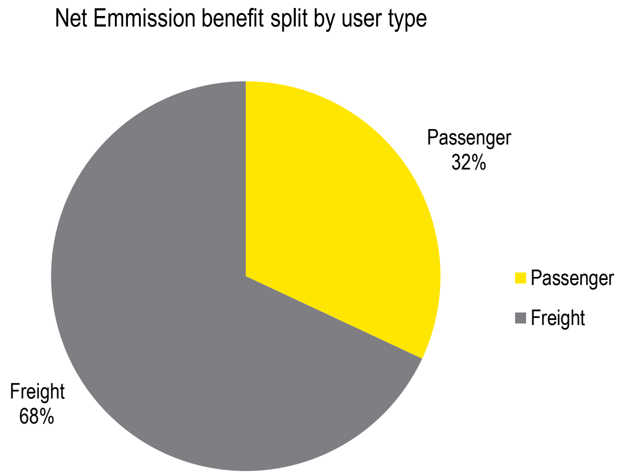
No.	Name	Reference	Date accessed	Limitations
Model	KiwiRail NTK Data	Kiwirail data (spreadsheet provided by email)	July 2016	▶ Small instances of possible double up removed from congestion costing. ▶ No Timing factor was present so was unable to tell when freight was moving along lines ▶ In some cases rail haulage was not allocated to a rail line, this was omitted from calculations
Model	Wellington Model Output	Greater Wellington Regional Council (provided by email)	July 2016	▶ No indication as to what the extra time from HCV additions to the road will have, therefore we had to approximate their congestion effect from light vehicle data. ▶ Assumes there is sufficient car parking capacity in the city to handle the increase ▶ Assumed output is for an average day and can be extrapolated for a whole year
Model	Auckland Model Output	Auckland Transport (provided by email)	July 2016	▶ Base year is 2013 and will not take into account large growth in rail patronage. ▶ Base year of 2013 doesn't take into account extra vehicle and busses on roads and changes to road infrastructure ▶ Outputs of change in vehicle times and vehicle distances appear too small and hence wellington model has been used to approximate these values ▶ To be conservative we have assumed only 70% of rail passengers transfer to the road and that bus network has sufficient capacity to handle the remainder. ▶ Assumes there is sufficient car parking capacity in the city to handle the increase ▶ Assumed output is for an average day and can be extrapolated for a whole year
Model	Average Auckland and Wellington Fare	https://at.govt.nz/about-us/our-role-organisation/meetings-minutes/	July 2016	N/A
Model	Average Auckland and Wellington trip length	https://at.govt.nz/about-us/our-role-organisation/meetings-minutes/	July 2016	N/A
Model	KiwiRail Freight charges	http://www.kiwirailfreight.co.nz/pricing.aspx	August 2016	▶ No exact charges were found for each and every single section of track so had to approximate it based on geographies ▶ This figure is likely to be the full 100% fee charged when in reality companies with commercial agreements with KiwiRail are likely to pay less with the locked in contract, however by including the full cost this is conservative.

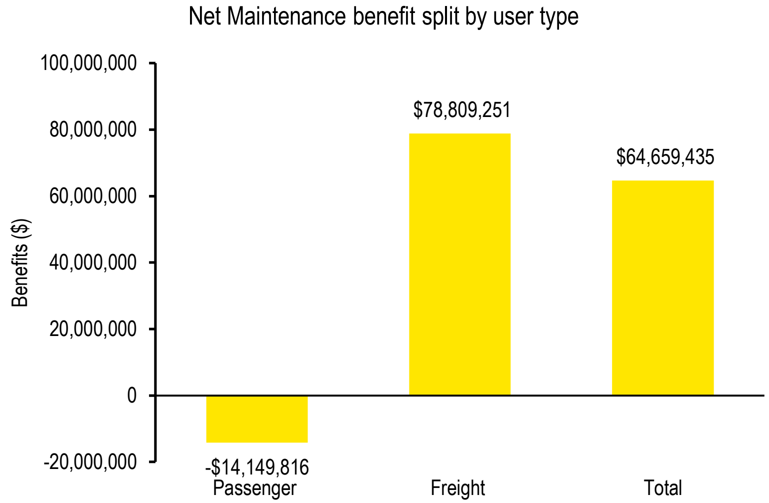
Appendix C Model Output Graphs

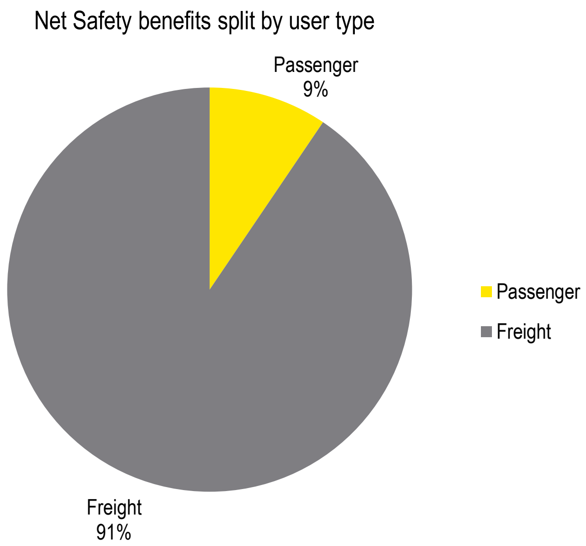




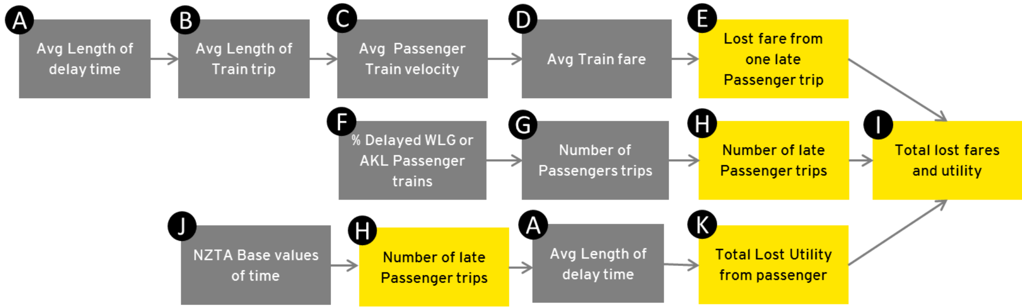



Net Emmission benefit split by user type
Passenger
32%
Freight
68%
Passenger
Freight


Net Maintenance benefit split by user type
100,000,000
80,000,000
60,000,000
40,000,000
20,000,000
0
-20,000,000
Benefits ($)
$78,809,251
$64,659,435
-$14,149,816
Passenger
Freight
Total


Net Safety benefits split by user type
Passenger
9%
Freight
91%
Passenger
Freight

Appendix D Rail Passenger Congestion Calculation



Index	Title	Description
A	Average length of delay time	Estimated based on time interval before train is considered late
B	Average length of train trip	Extracted AT board paper
C	Average Passenger train velocity	Based on relative distances between stations and National Rail System Standards Engineering Interoperability Standards (2013)
D	Average train fare	Extracted AT board paper and brought forward using Consumer Price Index to be conservative
E	Lost fare from one late passenger	Calculated by dividing A by the first division of C by B, then multiplying this D
F	% Delayed Passenger trains	Extracted from AT and MetroLink websites
G	Number of passenger trips per annum	From Ministry of Transport Public Transport volumes
H	Number of late passenger trips per annum	Calculated by multiplying F by G
J	NZTA Base valued of time	Extracted from NZTA EEM
K	Total lost utility from passengers per annum	Calculated by multiplying J, H, and A
I	Total lost utility and fare revenue per annum	Calculated by multiplying E by H and adding K

Appendix E Model Output Comparison Table

Value of Rail Model Comparison				
Topic	Deloitte Model (2013)	Steel Wheels Calculation (FY 2016)	Treasury (Budget 2015 Information Release)	EY Model (NZTA: Value of Rail)
Summary Comparison	**Safety - slightly lower than EY's calculation which included all injury types. Deloitte did not include all injury types and did not subtract the existing rail safety costs.** **Emission – Cost is larger than EY's due to higher than usual price of CO_2** **Congestion – Cost is lower than EY's as multiplier used is unlikely to capture full effects of congestion on all other vehicles** **Maintenance – Cost is higher than EY's as no net rail maintenance savings have been accounted for**	**Safety - No calculation** **Emissions – Lower than EY's value as passenger emission from extra light vehicles have also been accounted for. Different conversion factors used in converting NTKs to trucks** **Congestion – Steel Wheels did not cost freight congestion that would be imposed on the network but has calculated the trucks trips that have been taken off the road. This is smaller than EYs value** **Maintenance – Steel Wheels did not cost freight maintenance that would be imposed on the network but has calculated the trucks trips that have been taken off the road. This is smaller than EYs value**	**Safety – Benefits are less than EYs** **Emissions - Benefits are similar to EYs** **Congestion – Treasury stated extra RUCs will cover the expansion to remove congestion. EY's methodology is different to this** **Maintenance – Treasury stated extra RUCs will cover the maintenance. EY's methodology is different to this**	**N/A**
Safety	$42.93m ($27.6m of fatalities and $15.3m of serious injuries) Only considered freight not passenger rail which is largely why the EY total safety benefits is greater. EY model also included minor injuries costs which was not included in the Deloitte model. No existing rail safety costs have been subtracted in the Deloitte calculation making it larger than the EY figure.	No Calculation	$20m (freight only) .Treasury have also assumed that extra RUCs will be sufficient to address some of safety issues related to having more trucks on the road. EYs methodology is different to Treasury's.	$64m ($58.4m freight and $6.1m for passenger) This includes a safety analysis based on extra light vehicles and heavy vehicles km traveled.

Emissions	$22.4m This was greater than the EY figure because a higher price of carbon was used therefore increasing the emission value.	70.9m L of fuel savings, 192,752 Tonnes of CO_2 savings in FY2016 In comparison to EY's calculation KiwiRail's Steel Wheels have calculated much less fuel and emission costs than expected as they do not account for passenger rail emission and they convert their extra freight induced differently to EY. Steel Wheels use a conversion to truck trips and litres and from here calculated emissions, whereas EY has calculated it by using a multiplier for emissions per road NTKs.	$10m Slightly larger than EY calculation (no spreadsheet was attached to reconcile the difference)	$8.86m benefit ($6m freight and $2.8m passenger) which is 488,000 tonnes of CO_2 Calculated by applying an emissions-per-km/NTK multiplier to light veh.km and extra freight NTK required if rail task is transferred to road.
Congestion	$2.9m Analysis was only between Port and Wiri freight line. Value doesn't include analysis for other freight lines or any passenger service hence there is a large difference between values. Deloitte's methodology is different to ours in valuing congestion as they have estimated lost benefits from shutting the single freight line down in comparison to the EY comparative static analysis. Deloitte used passenger car equivalent units to produce a multiplier (Benefit$/veh/km) that could be used to times with the number of extra trucks on the road, hence treating benefits of removing extra trucks from road as equal to the benefits of removing extra light vehicles from the road. Treating trucks like light vehicles is similar to EY analysis and is conservative. The multiplier (Benefit$/veh/km) is unlikely to fully account for the congestion benefits experienced by other road users.	Steel Wheel calculated 983,000 truck trips avoided for financial year 2016. In the 2015 annual report this was reported as 1.4m truck trips. This appears smaller than EY calculated values and a likely cause is that the average load on trucks could be smaller in the EY calculation. No costing was given for congestion	No net benefit or cost Only a statement about how extra RUC will cover any extra capacity issues from extra truck freight that has been transferred from trains, although there will be a time delay in addressing these issues. EYs methodology is different to Treasury's.	$1.4b for entire network ($1.1b passenger and $0.3b freight (within Auckland gross freight benefits are expected to be $54.5m)). This includes passengers and freight networks avoided costs of congestion if traffic shifted off rail onto roads less the existing congestion on the rail.

	Existing rail congestion has not been subtracted from the Deloitte model			
Maintenance	$58.3m (Auckland -Tauranga corridor) The approach taken uses the EEM and is focused on a particular corridor rather than the entire freight task. Overall a very different approach taken. Extra RUCs have been subtracted from total extra road maintenance as a result of more freight. Whereas the EY study has calculated extra road maintenance using RUCs and subtracted existing rail maintenance. In the Deloitte model they have calculated the amount of extra loaded and unloaded freight VKT, but then applied a forestry loaded $/VKT (calculated with help of EEM) to all extra freight rather than applying different drivers for loaded and unloaded, resulting an increase of rail benefits. The EY study has estimated the maintenance on roads using RUCs per VTK. Existing rail maintenance has not been subtracted from the Deloitte model figure.	Steel Wheel calculated 983,000 truck trips avoided for financial year 2016 in the 2015 annual report this was 1.4m. This appears smaller than EY calculated values and a likely cause of it is the average load on trucks could be smaller in the EY calculation No costing was given for maintenance	No net benefit Only a statement about how extra RUC will cover any extra safety issues from extra truck that have been transferred from trains. EYs logic is different to Treasury's. Effects of Council Rates used to cover truck maintenance on urban roads not considered by EY or Treasury model.	$64m ($78.8m freight and -$14.1m passenger) We have assumed additional RUCs are a new cost on the economy and that they represent additional maintenance. This is avoided by rail hence it is a benefit that is offset by savings made from not having to invest in rail maintenance.

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