TE MANATŪ WAKA
MINISTRY OF TRANSPORT

Ministry of Transport | Domestic Transport Costs and Charges Study

Draft Report v2.1 | IWA/N285/DR1

August 2022

Contents

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Executive Summary

ES.1 The DTCC study

This is the draft report of the NZ Domestic Transport Costs and Charges (DTCC) study, which has been undertaken for the NZ Ministry of Transport by a consultant consortium led by Ian Wallis Associates Ltd. Peer review inputs have been provided by the Institute for Transport Studies at the University of Leeds, supplemented by a local review team of staff from MoT, WK and other government agencies.

The overall aim of the DTCC study was to identify all the costs imposed by the domestic transport system on the wider NZ economy and the *countervailing burdens,* including the charges faced by transport system users. Its outputs aim to improve understanding of the economic, environmental and social costs associated with different t transport modes, for freight and person movements, principally by road, rail and urban public transport.

The study commenced in early 2020. At that time, the last completed financial year (ending 30 June) for which data was available was 2018/19, so this was chosen as the analysis year for use throughout the study. In the event, this proved a fortunate choice, as the travel and transport data for years 2019/20 and 2020/2021 has been very significantly affected by the Covid-19 pandemic. Unless otherwise noted, all data in this report relates to FY 2018/19 and all cost and price data is expressed in 2018/19 prices.

The consultant work has involved the preparation of 26 working papers, which have each been subject to peer review. This report draws heavily on the more detailed work in those papers: these have included papers on walking and cycling, taxis and rideshare services, micro-mobility (e-scooters), the Cook Strait ferry services and coastal shipping services. A major focus of the work has been to analyse all modes on a comparable basis, starting from financial and usage statistics, broadening out to encompass economic statistics (such as costs of capital and values of time) and extending further to include socio-economic valuations on greenhouse gas emissions, local air pollutants, noise, public health impacts and accident (crash) impacts.

ES.2 Overview of economic and financial performance findings (main modes)

Table ES.1 (following) summarises our analyses on the financial, economic and social costs for NZ road and rail transport (each divided between person travel and freight transport) and for urban public transport (split between train, bus and ferry modes). The key results for the economic analyses are shown in rows 38-40, and for the financial analyses in rows 46-49.

The total economic costs for the three domestic sectors combined are some $127 billion for 2018/19. This represents approximately $25,000 pa per person in NZ.

Total economic costs include the following components:

- Infrastructure related costs
- Operation costs (vehicles and service provision related)
- Time costs
- Parking costs
- Social and environment costs:
    - Accident
    - Carbon emissions
    - Harmful emissions
    - Noise
    - Ecology and biodiversity

Some key features of these results (all on an annual basis, year 2018/19) are as follows:

- About 62% (or $80 billion) of the total economic costs can be attributed to road passengers, 35% ($44 billon) to road freight, 2% ($2.4 billion) to urban PT and 1% ($1.2 billion) to rail freight and long-distance rail passenger services.
- This dominance similarly applies to market shares for the three main modes. For freight movements (measured in ntk), road freight accounts for 87.4% of the market, rail freight for the remainder (but a greater share of the heavy freight market). For person movements (measured in pkm), road travel has a market share of 97.4%, urban PT (including urban rail) a share of 2.5%, and longer distance rail a minimal share of 0.1%.[1]
- Around 40% of the economic costs for both the roads sector and the UPT sector relate to travel time. In the roads sector, most of this relates to in-work (paid) time, split between road freight movements and mainly car-based business travel. In the UPT sector, travel time is largely unpaid (but still valued in economic terms), for a wide range of trip purposes (including commuting).
- For the roads sector, the environmental costs (GHG and local emissions, noise and ecology/biodiversity impacts) account for some 3% of total economic costs, about 7-8% for the rail sector and some 4% for the UPT sector. In addition, the economic/social costs of road accidents are notable here, approaching $7 billion pa, representing some 5-6% of the road system total economic costs.

The relationships between the total economic costs by sector and the total sector outputs (net tonne km for freight, person km for person travel) are of significant interest (refer rows 39,40). Notably:

i) for freight, the economic cost for road freight transport averages 145c/ntk and for rail freight 26c/ntk; and
ii) for person movements, the most relevant comparisons are 130c/pkm for road (mainly car) travel, 153c/pkm for urban PT travel.

However, considerable caution is advised in over-interpreting these modal relativities: inevitably, they represent averages over a wide variety of trip types in a wide variety of circumstances.

The net financial subsidy to road users overall (i.e., public sector costs minus user charges, row 46) is around $500 million (subject to a few caveats), meaning that charges paid by road users overall recover over 90% (row 49) of the public expenditure on operating, maintaining and improving the road system.,

For the rail system, the net financial subsidy is around $650 million, but in this case, charges paid by rail users recover only some 40% of the public expenditure on the rail system (rows 47-49). Somewhat similarly, the net financial subsidy to urban public transport is around $950 million, with PT user charges (fares) covering less than 30% of the public expenditure involved. Consequently, the average $ rates of financial subsidy to railway freight users and urban PT users (per person kilometre or tonne kilometre) are an order of magnitude higher than those to road users.

On the other hand, the share of combined user charges and other private costs as a percentage of total economic costs (see row 51) is higher for road transport (86% for private cars and 90% for road freight) then rail (see row 50, 35% for rail freight and 71% for long distance passenger).

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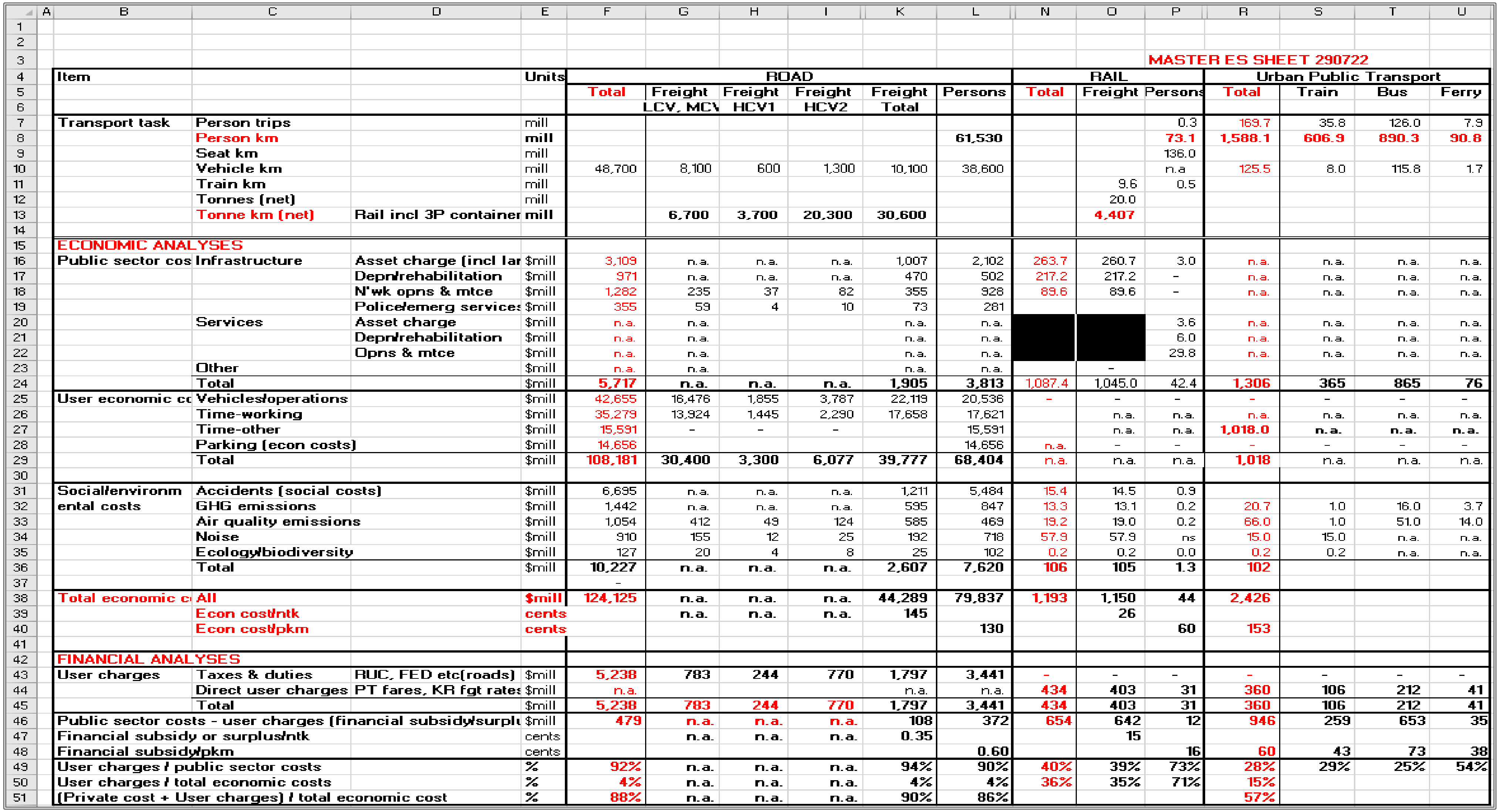
[1] These market share figures market share figures relate only to the three main modes for which comprehensive comparative analyses (as in table ES.1) has been undertaken. They therefore take no account of walking, cycling, flying, coastal shipping, micro-mobility and other minor modes.

Table ES.1 Economic performance by mode and market segment – Summary statistics (2018/19)



	A	B	C	D	E	F	G	H	I	K	L	N	O	P	R	S	T	U
1																		
2																		
3														MASTER ES SHEET 290722				
4		Item			Units	ROAD						RAIL			Urban Public Transport			
5						Total	Freight	Freight	Freight	Freight	Persons	Total	Freight	Persons	Total	Train	Bus	Ferry
6							LCV, MCV	HCV1	HCV2	Total								
7		Transport task	Person trips		mill									0.3	169.7	35.8	126.0	7.9
8			Person km		mill						61,530			73.1	1,588.1	606.9	890.3	90.8
9			Seat km		mill									136.0				
10			Vehicle km		mill	48,700	8,100	600	1,300	10,100	38,600			n.a	125.5	8.0	115.8	1.7
11			Train km		mill								9.6	0.5				
12			Tonnes (net)		mill								20.0					
13			Tonne km (net)	Rail incl 3P container	mill		6,700	3,700	20,300	30,600			4,407					
14																		
15		ECONOMIC ANALYSES																
16		Public sector cos	Infrastructure	Asset charge (incl lar	$mill	3,109	n.a.	n.a.	n.a.	1,007	2,102	263.7	260.7	3.0	n.a.	n.a.	n.a.	n.a.
17				Depn/rehabilitation	$mill	971	n.a.	n.a.	n.a.	470	502	217.2	217.2	-	n.a.	n.a.	n.a.	n.a.
18				N'wk opns & mtce	$mill	1,282	235	37	82	355	928	89.6	89.6	-	n.a.	n.a.	n.a.	n.a.
19				Police/emerg services	$mill	355	59	4	10	73	281							
20			Services	Asset charge	$mill	n.a.	n.a.			n.a.	n.a.	[redacted]	[redacted]	3.6	n.a.	n.a.	n.a.	n.a.
21				Depn/rehabilitation	$mill	n.a.	n.a.			n.a.	n.a.	[redacted]	[redacted]	6.0	n.a.	n.a.	n.a.	n.a.
22				Opns & mtce	$mill	n.a.	n.a.			n.a.	n.a.	[redacted]	[redacted]	29.8	n.a.	n.a.	n.a.	n.a.
23			Other		$mill	n.a.	n.a.			n.a.	n.a.		-					
24			Total		$mill	5,717	n.a.	n.a.	n.a.	1,905	3,813	1,087.4	1,045.0	42.4	1,306	365	865	76
25		User economic cc	Vehicles/operations		$mill	42,655	16,476	1,855	3,787	22,119	20,536	-	-	-	-	-	-	-
26			Time-working		$mill	35,279	13,924	1,445	2,290	17,658	17,621		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
27			Time-other		$mill	15,591	-	-	-		15,591		n.a.	n.a.	1,018.0	n.a.	n.a.	n.a.
28			Parking (econ costs)		$mill	14,656					14,656	n.a.	-	-	-	-	-	-
29			Total		$mill	108,181	30,400	3,300	6,077	39,777	68,404	n.a.	n.a.	n.a.	1,018	n.a.	n.a.	n.a.
30																		
31		Social/environm	Accidents (social costs)		$mill	6,695	n.a.	n.a.	n.a.	1,211	5,484	15.4	14.5	0.9				
32		ental costs	GHG emissions		$mill	1,442	n.a.	n.a.	n.a.	595	847	13.3	13.1	0.2	20.7	1.0	16.0	3.7
33			Air quality emissions		$mill	1,054	412	49	124	585	469	19.2	19.0	0.2	66.0	1.0	51.0	14.0
34			Noise		$mill	910	155	12	25	192	718	57.9	57.9	ns	15.0	15.0	n.a.	n.a.
35			Ecology/biodiversity		$mill	127	20	4	8	25	102	0.2	0.2	0.0	0.2	0.2	n.a.	n.a.
36			Total		$mill	10,227	n.a.	n.a.	n.a.	2,607	7,620	106	105	1.3	102			
37						-												
38		Total economic c	All		$mill	124,125	n.a.	n.a.	n.a.	44,289	79,837	1,193	1,150	44	2,426			
39			Econ cost/ntk		cents		n.a.	n.a.	n.a.	145			26					
40			Econ cost/pkm		cents						130			60	153			
41																		
42		FINANCIAL ANALYSES																
43		User charges	Taxes & duties	RUC, FED etc(roads)	$mill	5,238	783	244	770	1,797	3,441	-	-	-	-	-	-	-
44			Direct user charges	PT fares, KR fgt rates	$mill	n.a.				n.a.	n.a.	434	403	31	360	106	212	41
45			Total		$mill	5,238	783	244	770	1,797	3,441	434	403	31	360	106	212	41
46		Public sector costs - user charges (financial subsidy/surplu			$mill	479	n.a.	n.a.	n.a.	108	372	654	642	12	946	259	653	35
47		Financial subsidy or surplus/ntk			cents		n.a.	n.a.	n.a.	0.35			15					
48		Financial subsidy/pkm			cents						0.60			16	60	43	73	38
49		User charges / public sector costs			%	92%	n.a.	n.a.	n.a.	94%	90%	40%	39%	73%	28%	29%	25%	54%
50		User charges / total economic costs			%	4%	n.a.	n.a.	n.a.	4%	4%	36%	35%	71%	15%			
51		(Private cost + User charges) / total economic cost			%	88%	n.a.	n.a.	n.a.	90%	86%				57%			

Chapter 1: Introduction to DTCC - Setting the Scene

1.1 This report

This is the draft Final Report of the NZ Domestic Transport Costs and Charges (DTCC) study. The study was commissioned by the NZ Ministry of Transport (MoT) and undertaken by a consultant team led by Ian Wallis Associates Ltd.

The consultancy work has included extensive discussions with and provision of information by the MoT, other central and local government agencies involved in the transport sector and several other interested parties. Draft study outputs have been subject to peer review, principally by the University of Leeds (UK) Institute for Transport Studies, and also by NZ-based subject matter experts (principally from Waka Kotahi).

This report has been released as a draft for stakeholder engagement with and feedback from interested parties and individuals, which will include presentation and discussion sessions with transport sector stakeholders and other interested groups and individuals. Following this stakeholder engagement phase, it is anticipated that some changes to this report will be made in response to points made and information gained from submissions and other feedback provided: a final version of this report is expected to be published later in 2022.

1.2 Overview of study scope

The DTCC is the first comprehensive assessment of transport costs and charges in New Zealand since the Surface Transport Costs and Charges Study (STCC) in 2005. The STCC was a 'baseline' analysis of the costs of the NZ transport system(s) for the movement of persons and freight. It focused on the financial and economic costs of the road and rail systems, at both aggregated and segmented levels, and on how the charges levied on users and other parties related to the economic and social costs they imposed.

The scope of the DTCC study is considerably wider than that of STCC; in addition to road and rail, the DTCC covers a wider selection of transport modes/market segments, including:

- Urban public transport (bus, train, ferry) services
- Domestic sea freight transport[2]
- Active travel modes – walking, cycling
- Other road-based transport modes not covered in STCC – ride-hailing (including taxis) and micro-mobility (scooters etc.).

Further, and complementary to this wider selection of transport modes, DTCC's consideration of economic costs is wider in two main respects:

- a more detailed assessment of environmental costs (including greenhouse gas emissions); and
- the inclusion of the relative health cost implications of the different transport modes.

The DTCC is primarily concerned with the financial, social and environmental costs and impacts of the current NZ transport system together with the user charges associated with its use. It does **not** include an assessment of the **benefits** to transport users (or other parties) of their travel decisions (but noting that the distinction between transport system economic costs and transport user (dis)-benefit items is not clear-cut).

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[2] It was originally intended that DTCC would also cover domestic aviation. However, largely because of the Covid-19 pandemic, it proved difficult to obtain the required information from Air New Zealand and other airlines serving the NZ air passenger market: therefore, the work on the domestic aviation sector did not proceed beyond initial investigations.

The DTCC methodology was developed in the light of the different types of costs, charges and impacts that exist across the domestic transport sector, in terms of modes, market segments and differing levels of data availability. The organising framework for the study, as shown in Figure 1.1 below, summarises the scope of the work within three main topic areas, i.e. generic (cross-modal) topics, modal topics and impact topics. 26 detailed working papers have been prepared, covering the majority of these topics: a full listing of these papers is provided in appendix B.

1.3 DTCC outputs and potential applications

Transport costs and charges data is important for a wide range of transport policy analyses. It helps inform the value for money and financial sustainability of investments, as well as the size of the negative consequences of transport uses. It also helps answer a number of key policy questions, for example:

- What are the values of existing infrastructure assets? What are the costs associated with their maintenance, operation and renewal? What are the long-term financial implications regarding network or system expansions?
- Is the current transport system financially sustainable?
    - Are the current levels of charges sufficient to ensure assets can be maintained, renewed, upgraded and/or expanded?
    - What are the current levels of subsidies? Are the current levels of charges sufficient to pay for these subsidies?
- What are the average financial, social and full economic costs per passenger and tonne kilometre (for specific routes) by mode? What are the corresponding incremental/marginal and total costs?
- What are the average time costs of freight by mode?
- What are the social costs of transport emissions, noise and accidents by mode?
- Are transport policies, projects or programmes delivering value for money?
    - What is the size of the policy problems being addressed?
    - What are the potential economic, social and environmental benefits from transport policies, strategies and interventions?

The outputs of the DTCC study are **not** intended to directly deliver specific answers to transport policy questions. Rather, the study will contribute to the transport sector's understanding of how specific modes, and to the extent possible, specific subsets within modes (types of users, vehicle types, fuel types), impose costs on New Zealand's economy, environment, and population; and to what extent those costs are 'met' by charges paid (if any) for transport system use. The level of disaggregation of the study outputs will therefore help answer a range of transport policy questions, including those set out in the MoT Transport Evidence-Base Strategy[3], particularly those relating to transport funding and revenue topics.

The study collects important information for determining the effectiveness and efficiency of different modes of transport. Such information is important to encourage better utilisation of the existing network and thus increase economic benefits through productivity gains and reduction in transport costs (e.g., congestion). It will also help to better understand the external costs and impacts of the transport system on society and on the environment (including greenhouse gas emissions), which will help to inform policies aimed at reducing those costs and impacts.

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[3] Ministry of Transport: Transport Evidence Base Strategy (December 2019)

Figure 1.1: Organising framework for DTCC topics

Modal group	Mode	Freight/ Person	Report section	Working Paper reference	Coverage of impacts							
					Economic costs	User charges & revenues	Environmental & social costs					
							Accidents	Health	Local emissions	Global emissions (GHG)	Noise	Biodiversity & biosecurity
					Multiple	Multiple	D1, C11.6	D3	D4	D4	D5	D6
Roads	Cars, Light vehicles	P	4	C4, C5, C7	*	*	*		*	*	*	*
	Motor-cycles	P	4	C4, C5	*	*	*		*	*		*
	Trucks	F	4	C4,C5	*	*	*		*	*	*	*
	Bus & coach (non-urban)	P	7	C6	*	*	*		*	*	*	*
	Personal transport (taxi & ride-hail)	P	8.2	C9	*	*			*	*	*	*
	Micro-mobility (scooters etc)	P	8.3	C10	*	*						
	Walking	P	9.2	C8	*			*				
	Cycling	P	9.2	C8	*			*				
Railways	Rail freight	F	5	C11	*	*	*		*	*	*	*
	Rail passengers (long distance)	P	5	C11	*	*	*		*	*	*	*
Urban public transport	Urban bus	P	6	C12	*	*	*		*	*		
	Urban rail	P	6	C12	*	*	*		*	*		*
	Urban ferry	P	6	C12	*	*	*		*	*		
Coastal shipping	Coastal freight	F	10.2	C14	*	*	*		*	*		*
	Cook Strait - Freight	F	10.3	C15	*	*						
	Cook Strait - Passenger	P	10.3	C15	*	*						

The study outputs will also encourage policy decisions based on sound evidence in the transport and related sectors. Potential benefits include:

- Increased use of economic analyses in policy decisions when the full costs of transport use become available. When used with information on other benefits and costs of policy proposals, this information will improve our understanding of the "value for money" aspect of policy proposals.
- Consistent use of costs and charges information in policymaking if study results are clearly documented and are made available to wider audiences.

The study outputs have the potential for subsequent application in addressing a range of future policy issues related to the New Zealand transport system. When used with other tools and data, the DTCC outputs will help with:

- policy problem definition - by helping to define the significance of impacts
- multi-modal investment decisions and options assessment
- development of policies to reduce greenhouse gas emissions and other transport system 'externalities'
- understanding the effect of economic incentives on travel behaviour
- improving the transport funding and charging system.

1.4 Study documentation and reporting

Since the start of the study, the following documentation has been prepared by the consultant team:

- ***Scoping report (May 2020)*** *(see link here).*
- ***Working Papers -*** 26 detailed papers, mostly on a modal basis, were prepared over the period May 2020 - June 2022. A detailed listing is given in Appendix B. All working papers have been subject to review by the international peer reviewers and local subject matter experts from WK and other NZ government agencies. The finalised working papers will be made available through the MoT website in the coming weeks.
- ***Draft report (August 2022***) i.e., this report. This provides a summary of the study findings based on the working papers. It brings together the findings from all aspects of the study, including cross-modal comparisons.

Following stakeholder engagement and feedback on this draft report, it is envisaged that a final version will be prepared, taking account of feedback received.

1.5 Study participants

- ***Client.*** Ministry of Transport (NZ)

- ***Consultants***. The consultant project director was Ian Wallis (Ian Wallis Associates) supported by Barry Mein (Mein Consulting). The detailed work, including preparation of the working papers, was undertaken by subject matter experts from a number of consulting companies (largely based in NZ and/or Australia). Details of these companies and their subject matter experts are set out in appendix XX (??).
- ***Peer reviewers - international.*** International peer review was undertaken by the Institute for Transport Studies, University of Leeds (UK). The Institute is widely recognised as one of the leading transport sector academic groups internationally and has particular expertise in urban transport policy, economic and evaluation aspects. The ITS inputs were led by Prof Richard

Batley supported by Prof Peter Mackie. Their role included detailed review of all the working papers and of this draft report.

- ***Supporting reviewers – NZ.*** Most of the working papers were also reviewed by selected subject matter experts from NZ government agencies (principally Waka Kotahi). Their inputs were seen as important to ensure that local knowledge and perspectives were brought to bear in the study.
- ***Other stakeholders/interested parties.*** At an early stage in the study, NZ-based organisations and individuals were invited to register their interest in being involved and consulted in the study, either in general or on particular topic areas. A number of meetings/presentations and discussions were held with the parties who expressed their interest over the course of the study.

1.6 Confidentiality considerations

In general, once finalised, all significant reports, working papers etc. prepared by the study team will be available publicly on the MoT website.

Some, but limited, sections of working papers etc will be redacted at the request of specific parties, on the grounds of being ‘commercial in confidence’ to those parties - recognising that some parts of the NZ transport sector operate in competitive supplier markets.

1.7 Further contacts

The Ministry of Transport’s Project Manager for the DTCC study is Joanne Leung. Any enquiries or requests should be addressed to her in the first instance. Her contact details are as follows:

Email: j.leung@transport.govt.nz

Chapter 2: Overview of NZ Domestic Transport Sector

This (brief) chapter provides an essential context for the study, particularly for readers who are not very familiar with the way the NZ domestic transport sector is structured, organized, regulated and funded. This is set out in table 2.1:

- This covers the five main domestic transport 'modes', i.e., the road system, the rail system, urban public transport (covering bus, rail and ferry services), coastal shipping and domestic aviation.
- For each mode, it covers in turn: the assets involved and their ownership; the operations and the services provided; regulatory aspects, principally relating to safety aspects; and funding principles and arrangements.

Understanding the different nature of each mode is crucial to the study, as this is a major determinant of the roles of the public and private sectors, of the incidence of public subsidies and of the modal financial and economic performance.

The descriptions in the table relate primarily to the situation in financial year 2018/19. However, it should be noted that some changes in policy, regulation and funding have been (or are being) made since then, particularly in regard to rail policy: these are set out in more detail in the relevant report chapters.

Table 2.1.1: Overview of NZ domestic transport sector

Roads	Rail	Urban Public Transport	Coastal Shipping and Domestic Aviation
Assets and ownership			
Road network and infra: publicly owned via WK, LGAs (some via PPPs).	Rail network (3500 route km); rail infra & r/stock (freight and pax). Govt ownership via KiwiRail. Metro areas: urban pax r/stock owned by LGAs (refer UPT column).	Urban rail r/stock owned by RCs; services use KR-owned track under cost-sharing arrangements. Buses, ferries: owned privately (but AC negotiating to buy into current commercial ferry operations) Selected major infra projects (e.g., CRL) primarily Govt responsibility.	Ports: mainly owned by LGAs. Ships: private ownership (KR owns its Cook Strait ferries) Airports: mix of local/central government and private ownership. Aircraft: mixed Govt/pvt (Air NZ) ownership, or fully private
Services and operations			
Comprehensive public road network Cars, buses/coaches, m/cycles, trucks – all private	Mainly freight, limited passenger/tourist services. KiwiRail sets freight rates and passenger fares.	Bus services in all main towns; pax ferry services mainly AKL; Urban rail pax services AKL, WLG. Periodic competitive tendering to private operators. Service specs and fares defined by RC, gross cost contracts, revenues returned to RC.	Shipping – Cook Strait ferries: provide services for pax, freight, rail movements Shipping – other: limited domestic freight services – containers, specialist freight. Aviation: strong network of domestic passenger services (some freight/mail services).
Safety regulation			
MoT, WK, Police, TAIC	WK, TAIC Safety mgt: KiwiRail.	Safety reqts and other standards defined in operator contracts, monitored by RC.	Maritime NZ; Civil Aviation Authority, TAIC
Funding principles and arrangements			
Road network mtce and impts funded on PAYGO principle (mainly through NLTF, with LG contributions to local road funding). Separate govt funding for selected major projects (e.g., NZ Up programme). Revenues mainly from RUC (diesel) and FED (petrol). Some PPPs and toll roads; also, AKL fuel surcharge.	Government subsidies network via NLTF: intention is that Govt would fund the fixed network costs, while KR would recover the variable traffic-related costs from user revenues. RCs pay KR track access etc charges for use of metro network and facilities for their pax operations.	Funding through combination of fares, local/regional rates, Govt (NLTF). Previous target of minimum 50% cost recovery from fare revenues no longer maintained. Government grants for selected large projects, e.g., CRL, LRT, urban rail infra improvements.	Revenues mainly commercial. Some payments from LGA owners (for developments), or to them (dividends). LGA and/or central government subsidies to smaller airports.

Chapter 3: Economic Principles and Methodology – Transport Services and Infrastructure

3.1 Overview

Most New Zealand transport services are provided by private operators and government owned KiwiRail on a commercial basis. However, as in many other countries subsidy is provided to urban passenger transport and some rail services. There are no price controls and no restrictions on entry for privately-operated transport services provided on a commercial basis, other than basic health and safety requirements. The freight and long-distance public passenger transport markets are competitive, with prices largely dictated by the market. Urban public transport services are subject to entry restrictions, with operators generally chosen through competitive tendering processes.

Road transport operators, public transport operators, airlines and coastal shipping companies pay the resource costs of operating their services plus charges for their use of infrastructure that is provided by other parties (Waka Kotahi, airport and port companies). Their total costs are reflected in the fares and rates they set (and PT subsidies). For the railway system, the infrastructure is provided internally by KiwiRail. KiwiRail aims to covers its costs (which, in the study year, included its infrastructure costs and operating costs) by pricing based on what the market will bear, although in practice significant subsidies have been paid.

The cost and charging methodologies addressed in this paper are relevant within infrastructure providers, between them and operators, and for public policy analysis of related subsidies[4].

3.2 Economic approach to accounting for costs

3.2.1 General issues

All transport operators face direct operating and maintenance costs such as wages, energy, repairs and maintenance, taxes, insurance, and payments to suppliers. These (and revenue) are recorded in profit and loss accounts and cashflow statements. For commercial and policy decision-making, this financial cost information needs to be supplemented with analysis of wider economic and social costs – the main subject of this chapter.

An economic approach goes beyond the direct financial information and considers total costs over time. It considers both present and future costs caused by current activity – for example, increased use of a road or a railway will advance the time when refurbishment is needed, and that cost should be recognised in the current period rather than left for the period when the actual expenditure occurs (unless a decision has been made to run the asset down).

The economic approach also considers the cost of capital – that is, the return (like an interest rate) that the investor requires in order to invest in that activity rather than elsewhere. Methodologies for this are discussed below, notably the weighted average cost of capital (WACC). (In some public sector contexts there may in practice be no such return, but the government (and subsidy provider) itself faces borrowing costs which should be recognised).

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[4] This chapter relates to the situation in 2018/19, but subsequent significant developments in policies and practices are also mentioned.

3.2.2 Social costs

A further broadening of cost coverage, which has attracted increased attention in recent years, is full social cost – that is, the full costs borne by wider society as a result of the transport activity. The main social costs are greenhouse gas emissions, particulate emissions, congestion, accidents and noise. Some transport activities add to these social costs, while others may reduce them: for example, a good public transport system can result in less use of cars, and hence in reductions in emissions, congestion etc.

An efficiency principle is that transport users should be faced with the full costs that their transport use imposes on the wider community, so that they make decisions about transport use with full information on the costs they impose, such as pollution, safety and congestion.

One dimension of policy and accountability is what costs (and revenues) are relevant, and how they are measured. Another dimension is 'getting the prices right' --- here there are choices to be made between full cost pricing and marginal cost pricing. These choices lie at the heart of transport policy making and involve complex trade-offs between equity and economic efficiency.

Methodologies for considering wider social costs can be more complex than those for direct financial costs. For example, the social costs caused by particulate emissions and noise are generally higher in densely populated areas than in the countryside (unlike the social costs of greenhouse gas emissions which are independent of location and circumstances in which they occur). An extra vehicle imposes higher congestion costs on a busy road than on a lightly used road. Some safety costs are imposed on the wider community (e.g., a crash that harms third parties) while others are borne by the user.

To sum up, costs can be regarded as three rows in a table: financial costs, economic costs and (net) social costs.

3.3 Economic approach to accounting for costs – modal issues

3.3.1 Road system issues

Road transport infrastructure is provided by central government (via Waka Kotahi) for state highways and by local authorities (for local roads). It is funded through a 'pay as you go' (PAYGO) system, which recovers from road users each year all (or most of) the public sector financial expenditure on the road system in that year. Revenues come from petrol tax, road user charges on diesel and (in future) electric vehicles, vehicle registration and relicensing fees. There is also a contribution from local authority rates for local roads, and in some years the government supplements this revenue with additional payments, e.g., from the Provincial Growth Fund.

The New Zealand (PAYGO) system is a particular example of what is commonly known as a **fully allocated cost (FAC)** approach to the pricing of public road infrastructure, which is widely used internationally. Particular features of the New Zealand road financing system are that:

- Charges from the various revenue instruments are set to recover the expenditure on or related to roads (maintenance, capital upgrades, safety enforcement and a contribution to public transport) in the year in which it occurs.
- As capital investments are recovered from annual revenues, no future depreciation or interest is charged.

- Costs are allocated between different classes of users by vehicle type using a Cost Allocation Model (CAM) that broadly reflects economic, accounting and engineering principles.
- Non-financial costs (e.g., costs of congestion) may be caused by road users, but are not generally recovered from road the users as a group (e.g., through a congestion pricing scheme). There are some exceptions (e.g., the ETS levy on fuel prices). However, users also indirectly face any mitigation costs incorporated in road investment, safety and maintenance work (e.g., through inclusion of noise barriers) -- which are reflected in the allowance for Wider Economic Benefits in cost: benefit calculations.

The current system of paying for roads is generally regarded (by economists) as inefficient[5] in that its charges are system-wide averages that do not reflect the costs imposed by particular users on particular routes. In the past such crude pricing may have been unavoidable because of the impracticality of monitoring road use in detail. Technological improvements such as telematics (vehicle monitoring systems) and electronic road pricing are now making more targeted pricing technically feasible and financially viable. But the balance to be struck between economic efficiency, cost recovery, equity between user classes and rural v urban etc is ultimately a policy, and indeed a political question.

Road transport operations are funded by users of the road system, either directly or indirectly: directly in the case of private cars/light vehicle users, who pay through fuel taxes; and in other cases, indirectly through charges to customers set by road freight and bus/coach companies, who in turn pay road user charges (RUC) to the government.

3.3.2 Rail system issues

Rail infrastructure has been, and continues to be, funded primarily from government capital injections. Regional authorities also make contributions (through "track user charges") towards maintenance of track and other rail fixed assets in metropolitan areas (refer the next section for further details on the accounting/funding arrangements for metropolitan rail services).

Recent new legislation provides for accounting separation within KiwiRail between infrastructure and operations, which will (among other factors) clarify the basis for track user charges. These charges will be paid initially by the customers of KiwiRail's operations arm and passed on as appropriate to their infrastructure side, to cover the variable costs of KiwiRail's provision of infrastructure services.

KiwiRail does make payments, through the costs of diesel fuel, towards the greenhouse gas emissions resulting from the burning of fossil fuels, as occurs in the roads sector. Apart from this, it does not make payments to cover other external costs such as air pollution, noise and biodiversity. These external costs arising from rail transport are generally small relative to the equivalent costs arising in the roads sector

Further details of rail funding are provided in working paper C11.4.

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[5] An efficient price is one which sets use charges so as to cover the marginal costs of supplying the service and creates the right signals to ensure that transport is only used when its benefits exceed its costs. Since network facilities such as roads and railways have high initial installation and fixed costs, this approach does not guarantee revenue will match expenditures in any one year or even over the longer term.

3.3.3 Urban public transport issues

The regional authorities (including Auckland Transport) provide urban passenger services by rail (Auckland, Wellington), ferry (various regions, principally Auckland) and bus (all regions). In (almost) all cases, the required services are procured from private operators through periodic competitive tendering for contracts, which provide successful operators with area or corridor monopolies over the term of their contracts. Service levels and fares are determined by the regional councils, with fare revenues being collected by the operators and returned to the councils.

Bus operators pay road user charges (on a comparable basis with truck operators) for use of the road network. For the metropolitan rail services, the two regional authorities have contracts with KiwiRail to share the costs (with freight services) of providing and operating rail infrastructure in their metropolitan areas.

Most of the public transport services are heavily subsidised, with on average less than 50% of their total costs being covered from fare revenues. The subsidies are funded through a mixture of regional/local rates and central government funding (through the NLTF). This applies to almost all services provided by the three PT modes, although some services in Auckland (principally by ferry) are provided on a commercial (non-subsidised) basis with their operators being free to set their own fares and service levels.

3.3.4 Other modes

Coastal shipping and domestic aviation operate largely on a commercial basis, except for subsidies to some of the smaller ports and airports. The shipping companies and airlines earn revenue from customers, face their own direct costs and pay port and airport companies on a commercial basis for infrastructure services. There is relatively little government involvement.

3.4 Marginal costing approaches – short and long run economic costs

This report considers four alternative costing concepts that may be used to define the quantum of costs to be covered in land transport systems:

- Fully allocated costs (FAC) and the PAYGO variant currently adopted in the NZ roads sector
- Short run marginal costs (SRMC)
- Long run marginal costs (LRMC)
- Marginal cost-plus mark-up (MC Plus).

FAC/PAYGO (refer earlier section 3.3.1) is the most common approach adopted internationally to charging for public road infrastructure. It has the advantage of relative simplicity and an appearance of fairness, with a focus on full recovery of financial costs.

SRMC is defined as the change in the total social costs (i.e., the sum of private and external costs) resulting from a unit increase in use (including any future costs caused by current use), based on the current level of infrastructure provision. External costs include congestion, so SRMC is relevant to debates on the merits of congestion pricing. SRMC is generally advocated as the primary basis for pricing in the economic literature as it provides a guide to the most efficient use of existing infrastructure.

LRMC is defined as the change in the total social costs resulting from a unit increase in use, allowing for capacity and infrastructure provision being optimally adjusted in the long run to match the level of use. LRMC is seen as having a primary role in long term investment decisions. It may also provide a good guide to the equilibrium value of the SRMC.

MC Plus. Unlike FAC/PAYGO, neither SRMC nor LRMC guarantee full recovery of actual (financial) costs or expenditures. The revenues generated may be greater than or less than the annual expenditure on network operation and maintenance. One approach to MC Plus is to apply a mark-up to SRMC to achieve the stated cost recovery or revenue target: this may be achievable in situations where the customers are not highly price sensitive. [6]

3.5 Valuation of Capital Assets - Economic performance and economic cost recovery aspects

3.5.1 Asset valuation approaches

Besides financial, economic and social costs, the report discusses issues of asset valuation and the cost of capital, and how these relate to charging a capital return. A number of valuation approaches are available.

- **Depreciated Historical Cost (DHC)** is the original purchase or construction cost (including later improvements) less an allowance for depreciation based on an assumed economic life. It is sometimes used in company accounts but rarely used in decision-making as the costs may have arisen long ago.
- **Depreciated Replacement Cost (DRC)** values the asset at its current replacement cost less an allowance for depreciation based on an assumed economic life: it differs from historical cost when costs have changed over time (due to inflation or other factors).
- **Optimised Depreciated Replacement Cost (ODRC)** values assets at the cost of replacing the functions performed by a currently optimal configuration of assets (rather than direct replacement of all the current assets in their original form). It excludes redundant or obsolete assets and is relevant where technological or economic changes shift demand for services and/or costs. This approach is frequently used by New Zealand and Australian businesses: it has been applied in the DTCC analyses of KiwiRail's principal asset values.
- **Opportunity Cost** is the value of an asset in its most productive alternative use and is a measure of the cost to the economy (or a company) of continuing to use the asset for its current purpose. Only recoverable assets that can be salvaged or used elsewhere have an opportunity cost, and value in alternative use is net of the cost of converting it from its current use. Opportunity cost is a valuation principle implicit in all the replacement cost approaches, as it is used to value the resource inputs in defining replacement cost.
- **Deprival Value** is the loss that the current asset user would suffer if the asset were no longer available: it combines elements of the concept of replacement cost and that of the value of revenue streams generated by the asset.

Although opportunity cost is an economic concept for valuing assets, the return on this basis may provide insufficient incentive for new investment to cover upgrade or expansion. Some return in excess of opportunity cost may be warranted, as provided by optimised depreciated replacement cost. In practice, however, this is often difficult to estimate.

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[6] Other variants of the MC Plus approach exist (e.g., involving 'Ramsey pricing'), but are not addressed further in this report.

These valuation approaches are indicative only and need to be treated with caution. The report has examined separate DRC components for:

- Depreciating recoverable assets, such as track.
- Non-depreciating recoverable assets, principally land - which is commonly valued on the basis of the values of land adjacent to the road or railway
- Non-recoverable ('sunk') assets, including some formation, tunnels and bridges (both road and rail): these may have little (if any) value in alternative uses after allowing for recovery and re-purposing costs.

In the case of the road network, the asset calculations include no depreciating assets, only land and non-recoverable assets. With regard to land, this is commonly valued using an 'across the fence' approach, i.e., valuing the land at the same rate as any adjacent land. In many cases, particularly with the road network, this is problematic. Roads provide a valuable access function to adjacent land and, if the road was no longer usable, access would be more difficult or impossible and the value of the adjacent land would significantly reduce.

In terms of other non-recoverable assets, 'non-recoverable' may be a fair description for road formation, base-courses and surfacing: in any event, the practices adopted by Waka Kotahi and local councils are generally to maintain the existing road network in a 'steady state', such that its value does not depreciate significantly over time. But the road network also includes assets such as traffic signals and lighting that may be partly salvageable. These are difficult to value, and the road valuation may be understated as a result. Accordingly, the report has adopted the more practically tractable approach of including sunk costs in its valuation.

3.5.2 Cost of capital

The cost of capital for any investment is the rate of return that capital investors would expect to receive they were to invest the capital on a project elsewhere with comparable risks. In other words, the cost of capital is an opportunity cost.

Companies create value for their shareholders by earning a return on the invested capital that is above the cost of that capital. **WACC** (Weighted Average Cost of Capital - refer WP B5) is an expression of this cost and is used to see if intended investments are worth undertaking. WACC is expressed as a percentage, like interest. If for example a company works with a WACC of x%, then only (and all) investments should be made that give a return higher than this.

The study has adopted a WACC rate of 4% (real terms), based on its appraisal of evidence on the returns in the wider transport and related sectors in New Zealand. This is consistent with the discount rate adopted by WK as its central estimate for cost: benefit analyses of transport investments proposed for public funding. This WACC rate has been adopted throughout DTCC in its valuations of capital assets, principally in the roads and railways sectors.

Requiring full cost recovery including a return on assets employed differs from the PAYGO approach where the capital 'charge' is an allocation of the cost of new work in the year in question. However, if assets are long-lived and trend growth is steady, it can be shown that PAYGO will give the same capital charge as applying a cost of capital to the DRC.

3.6 Summary - Modal Comparisons

Looking across the transport modes, differences in their basic economics result in differences in their charging regimes. Starting from a simple commercial model and building up in complexity, we have:

- ***Coastal shipping (and domestic aviation) operators*** – these are commercial services and have straight-forward commercial charging regimes. They charge their customers, and they pay their infrastructure providers. However, we note that proposals to pay subsidies have recently been announced in the case of coastal shipping[7].
- ***Road freight and long-distance coach/bus services --*** these are also commercial in nature. They pay for their use of infrastructure (roads) on a pay-as-you-go basis. The amounts they pay are determined by an allocation formula between vehicle types that reflects financial costs in that year for road maintenance, operation and construction. Detailed exceptions to this are discussed in the working papers.
- ***Urban public transport*** -- also pays its 'fair share' for its use of infrastructure (roads and rail lines), but only part of its revenue is commercial (farebox): a substantial proportion of revenue comes from regional/local and central government subsidies of various types.
- ***Railway --*** covers a substantial proportion of its total costs from user revenues (largely from freight traffic). KiwiRail (with Government) is moving towards a policy under which it would be expected to recover its 'above rail' (operational) costs from users, but with government funding (subsidies) to largely cover the fixed costs of its network infrastructure.

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[7] https://www.beehive.govt.nz/release/government-investment-boosts-coastal-shipping-aotearoa

Chapter 4: Road System Appraisal

4.1 Key road network and road usage statistics

The New Zealand road network (controlled by Waka Kotahi and the local authorities) extends to about 97,000 kms in 2018/19. Of this total, about 11,000 kms were operated as State Highways by Waka Kotahi and the balance of 86,000 kms were local roads managed by the various territorial local authorities. Some 64,200 kms were sealed with about 32,400 (33 per cent} unsealed. While Canterbury has the longest road network overall, in part reflecting its size, Waikato has the greatest length of State Highways, reflecting the complexity of longer-distance routes in the region.

4.1.1 Usage of the road network

In 2018/19 the total number of registered vehicles in New Zealand was about 4.2 million. The breakdown of this number by vehicle type and the estimated distance travelled in the year is set out in Table 4.1.1.

Table 4.1.1: Vehicle numbers and distance travelled by vehicle type 2018/19

	No of vehicles (1)		**Distance travelled (bn kms) (2)**	
Vehicle type	**Total (000s)**	**Per cent**	**Total**	**Per cent**
Motorcycles	176.7	4.2%	0.4	0.8%
Cars	3298.5	77.5%	35.7	73.5%
LCV	621,1	14.6%	9.1	18.7%
MCV	89.6	2.1%	1.1	2.3%
HCV	59.2	1.4%	2.0	4.0%
Bus	11.4	0.3%	0.3	0.6%
Total	**4256.5**	**100.0%**	**48.6**	**100.0%**

In terms of person travel (i.e., excluding goods vehicle drivers), roads were used for about 62 bn person kms. Of these, car accounted for 55.7 bn (91 per cent), motorcycles for 0.4 bn (1 per cent), buses for 3.1 bn (5 per cent) and other vehicles for 2.3 bn person-kms (4 per cent).

The total freight task (including goods carried in light goods vehicles) is estimated to amount to about 32 bn tonne-kms annually. The breakdown of this by goods vehicle type is set out in Table 4.1.2.

Table 4.1.2 Estimated breakdown of the total road freight task by goods vehicle type 2018/19

Vehicle type	**Billion tonne-kms**	
	Total	**Per cent**
LCVs	4.6	15%
MCV	3.2	10%
HCVs	24.0	76%
Total all	31.7	100%

In total HCVs which make up about 8 per cent of the commercial vehicle fleet carry about three-quarters of the road freight task. LCVs, although individually having a limited carrying capacity, are very numerous and together contribute about 15 per cent of the total tonne km.

The usage of the road network by road type (SH, LR) and vehicle type (light, heavy) is set out in Table 4.1.3.

Table 4.1.3 Estimated breakdown of traffic by road and vehicle type 2018/19 (billion vehicle km)

Road type	**Urban**			**Rural**			**Total all roads**		
	Light	**Heavy**	**Total Urban**	**Light**	**Heavy**	**Total Rural**	**Light**	**Heavy**	**All vehs**
Local Roads	12.7	0.4	13.1	11.2	0.7	11.9	23.9	1.1	25.0
State H'ways	8.5	0.6	9.1	13.0	1.8	14.8	21.5	2.4	23.9
Total	21.2	1.0	22.2	24.2	2.4	26.7	45.4	3.4	48.9 (1)

Notes (1) Because of the approach used to calculate these figures, this total differs slightly from the total in Table 4.1.1

Source: WP C4, Appendix D

The key findings from this table include:

- The State Highway network accounts for just under 50 per cent of the total vehicle kms but for only about 11 per cent of the length of the total road network.
- The State Highways also carry a high proportion, about 70 per cent, of heavy vehicle movements.
- Urban roads account for about 47 per cent of light vehicle travel but only 29 per cent of heavy vehicle travel.

4.2 Valuation of the road network

4.2.1 Introduction

The value of the road network is an integral component in the total costs of providing and maintaining the road system, whether this value is measured in financial or economic terms. This section outlines the basis of valuation for the New Zealand road network and the values that result.

In 2018/19 the value of the NZ road network was estimated at some $110bn average ($22,000 per capita). Of this some $61.5 bn is for local roads and about $50 bn for State Highways.

4.2.2 Basis of valuation

For the valuation of the road networks, the road infrastructure and the land that it occupies are valued separately.

Waka Kotahi and the local authorities all use a broadly similar approach to valuing the roading infrastructure. This is based on the replacement costs of the various components with an allowance for the depreciation of these over time as and where appropriate.

However, for the valuation of land, an important component of the total, a variety of different approaches are used. In all cases, it is assumed that land does not depreciate in value over time (unlike most of the other components making up the total valuation). Waka Kotahi takes an "over the fence" approach, which values the land used by highways on the basis of the land prices for the areas adjacent to the road. This gives land costs a value of about 28 per cent of the total depreciated value of the State Highway network. These estimated values are updated regularly.

For the local authorities the approaches used to value the land assets vary and the outcomes are not always published. The lack of a consistent approach to the valuation of land means that the figures for this should be regarded as indicative rather than precise. The land values are estimated at about 31 per cent of the total value of the local road network, reflecting the high share in urban areas, where land costs are typically high. Because of the use of historic costs in some of the valuations, it appears likely that the land values for local roads may be significantly under-stated in relation to the approach used by Waka Kotahi.

4.2.3 Summary of road network valuations by roading authority

The aggregate values of the road network for the State Highways and local roads are set out in Table 4.2.1. The total depreciated value of just over $110 billion is split about 45 per cent for SH and 55 per cent for local roads. The land values, which amount to about 30% of the total values of the road network, are the only asset category which is classified as recoverable.

Table 4.2.1: Summary valuation estimates for the New Zealand road network 2018/19

Item	**Depreciated Replacement Cost**	
	Total $bn	**Per Route Km $m**
Road category:		
State Highways	49.7	4.50
Local Roads	61.5	0.72
Sub total	**111.2**	
Analysis by Asset Category		
Recoverable, non-depreciating (land)	33.4	
Non-recoverable (all other asset types)	77.8	

Notes (1) This assumes a similar relationship between replacement costs and depreciated replacement costs for the local road network as was determined for the State Highway network.

The average value per road km for State Highways is very much higher than that for local roads. This reflects in part the higher capacity and construction standards of much of the State Highway network and in part the different assumptions about the value of land.

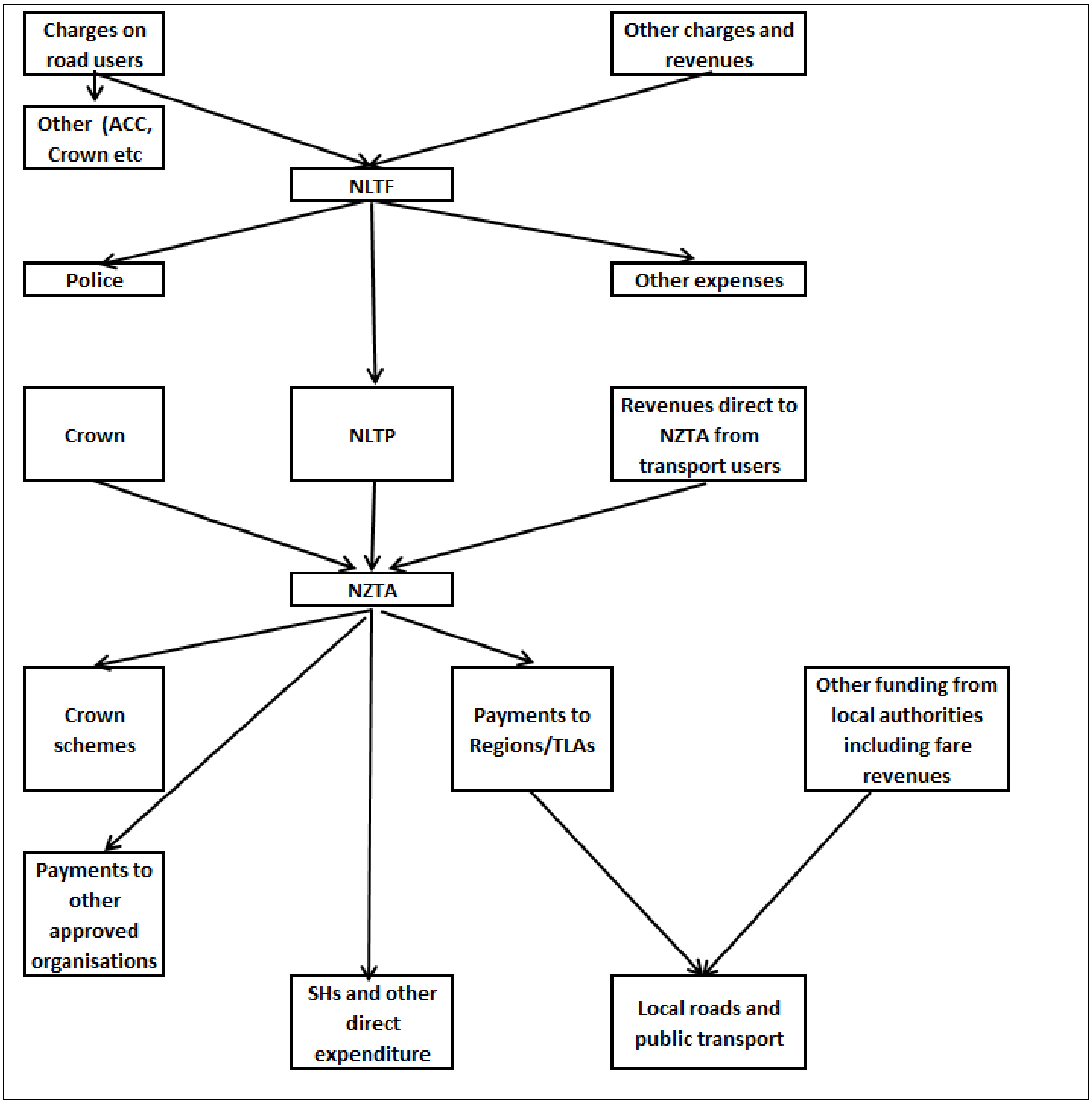
4.3 Public expenditure on the road system

4.3.1 Overall structure of revenues and expenditures

The total public expenditure on the road system in New Zealand in 2018/19 amounted to about $4.8 bn.

The broad structure of the total charges to road users and others for the use of the road network together with the agencies responsible for the spending of the revenues collected is set out in **Error! Reference source not found.**.

Figure 4.3.1 Outline structure of roading and public transport revenue and expenditure flows



The bulk of the funding for the roads system is derived directly from users. In addition, local authorities make contributions from their own resources (largely raised through local rates) to support local schemes. The Crown (central government) also makes a direct contribution in respect of a range of defined schemes, the Kaikoura earthquake response currently being the largest of these. Some of the funding from road users goes to support the public transport activities of the regions in conjunction with revenues from users and other local authority funding.

4.3.2 Basis of the funding and charging system

The major principle underlying the charging and funding approach is that all expenditure in a year (both capital and operating expenditures) should be financed from funds generated in that year (PAYGO). There are some exceptions to this, particularly in the financing of PPP projects such as Transmission Gully and other tolled projects, the revenues from which are used to offset their capital costs over time.

4.3.3 Annual expenditure on the road system

The expenditure on the road system is primarily funded from a variety of charges paid by road users which are channelled through the National Land Transport Fund to Waka Kotahi. This is either spent directly by Waka Kotahi on the State Highway network or is passed on to other agencies mainly for the local road network and to support public transport. The revenues from users are supplemented by grants from the Crown for specific schemes (particularly in recent years repairing the damage from the Kaikoura earthquake) and by funding from local authorities[8] for both roads and public transport.

The total cost of providing and managing the road system on a PAYGO basis in 2018/19 is estimated at about $4.8 bn. The breakdown of the sources for the expenditures is set out in **Error! Reference source n ot found.**.

Table 4.3.1 Sources of expenditure on the road sector 2018/19 ($m)

Source of revenues	**Total**	**Per cent of total**	**Notes**
Waka Kotahi (direct revenues from road users)	3,709	78%	Includes contributions to expenditures on policing and subsidy to local authorities
LAs own resources	849	18%	Estimated. As well as rates, this includes revenues from road users from for example parking, LAPT, RFT etc but this is not ring fenced
Crown	198	4%	Payments for identified projects
Total	4,757	100%	

About three-quarters of the funding supporting the expenditure on managing and developing the roading network comes from Waka Kotahi, using the revenues mainly collected from road users through fuel excise duty, road user charges and vehicle license fees. A further 20 per cent comes from local authorities. The Crown also directly provides a small part of the total, much of which in 2018/19 related to the payments for the Kaikoura earthquake response and so would vary from year to year.

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[8] Waka Kotahi provides support to the local authorities through subsidies for "Approved Projects", for which the local authorities typically have to provide a portion of the expenditure. However local authorities may also spend on projects which are not approved by Waka Kotahi and for which they therefore have to meet the full costs. Information on the expenditure by the local authorities is only available from their 63 Annual Reports and not with a consistent breakdown. Estimates have been made of this expenditure based on a sample of the authorities

Of the revenues collected by Waka Kotahi and used to fund the roading system, the subsidy to local authorities is estimated at $1,398m in 2018/19. The balance remaining with Waka Kotahi is divided between expenditure on the State Highway system, subsidies for other agencies, and general staff and operating expenses.

4.3.4 Breakdown of roading expenditure by type

The Waka Kotahi accounts and supporting data provide a detailed breakdown of the types of expenditure on the roading system. However, not all local authority expenditure is included in this and there is no published breakdown of the expenditure by local authorities on a similar basis. We have however made estimates of the nature of this expenditure based on the breakdown of approved expenditures, but these should be regarded as indicative only. It should also be noted that in the absence of any details of the breakdown of Crown expenditure by road type, it has all been allocated to the State Highway network, reflecting the predominance of expenditure on the Kaikoura earthquake response.

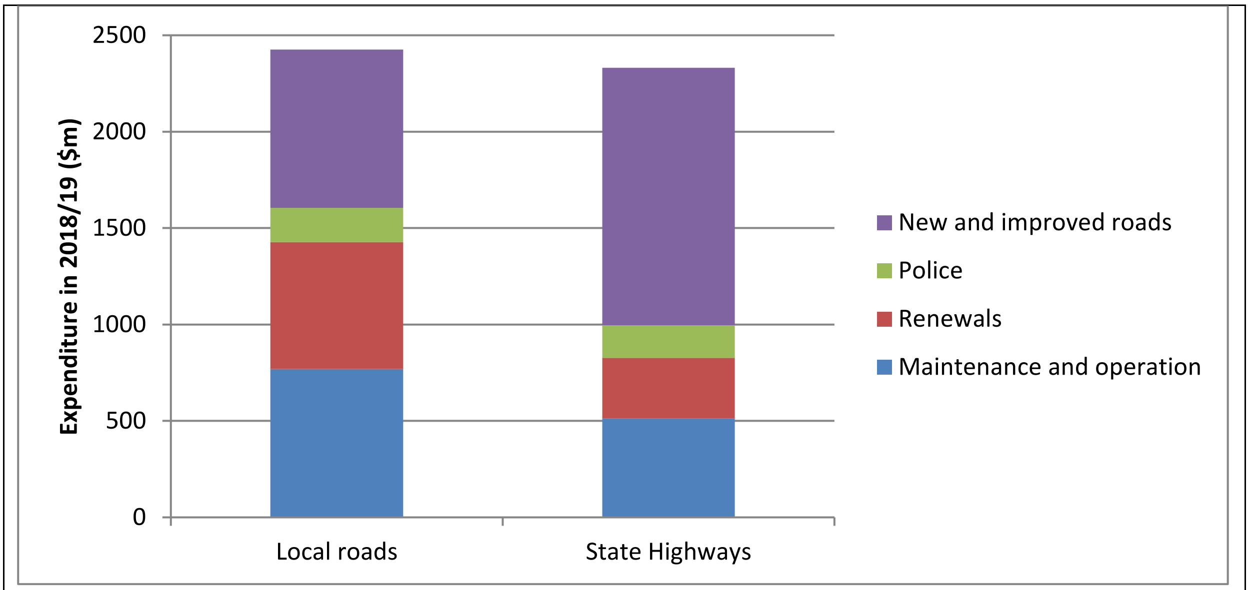
The estimated breakdown of expenditure by type is set out in Table 4.3.2.

Table 4.3.2: Estimated breakdown of roading expenditure by road type 2018/19, PAYGO approach

Expenditure type	**Road type**					
	State Highways		**Local roads**		**Total**	
	$m	**Per cent**	**$m**	**Per cent**	**$m**	**Per cent**
Maintenance and operations	514	22%	769	32%	1,282	27%
Renewals	313	13%	658	27%	971	20%
Policing (1)	170	7%	178	7%	348	7%
Total operations & mtce	***997***	***43%***	***1,605***	***66%***	***2,602***	***55%***
New and improved roads	1,335	57%	820	34%	2,155	45%
Grand total	**2,331**	**100%**	**2,425**	**100%**	**4,757**	**100%**

Notes (1) Police costs have been allocated in proportion to the total veh-kms by road type. See Table 4.1.3

Figure 4.3.2: Breakdown of operating and capital expenditure by road type 2018/19 ($m)



Although the total estimated expenditures on the State Highway and local roads networks are broadly similar in aggregate terms, there is a very different split for the two road classes between expenditure on operations and maintenance on the one hand and capital costs on the other hand. Local roads have a much higher proportion (and absolute level) of expenditure in operating and maintaining the asset in terms of both maintenance and renewals, whereas for State Highways there is a much greater focus on expenditure relating to the provision of new roads. For State Highways this amounts to about 57 per cent of the total ($1335m) whereas for the local road network, this only amounts to about 34 per cent of expenditure ($820m). This difference applies to both the basic maintenance of the asset and the level of renewals, with both being higher for the local roads' component in dollar terms and also as a proportion of the total.

4.3.5 Alternative approaches to the assessment of the costs of the road system – valuing the return on assets

The level of capital expenditure which is financed by road users on the current PAYGO basis, as set out in Table 4.3.2, can be compared with charges that would be required to obtain the desired rate of return on the capital assets embodied in the roading network. As Table 4.3.2 indicates, the capital expenditure on the road network in 2018/19 that was financed on a PAYGO basis by users or by the local authorities or by the Crown from general tax revenues amounted to about $2.2bn.

An alternative approach is to consider the extent to which the contributions from the various parties would compare with the charges that would be required to obtain a suitable rate of return on the assets employed in the road system. Work as part of this study has identified that a suitable rate of return on assets for this purpose would amount to 4 per cent which if applied to the non-recoverable assets in the road of $77bn as set out in Table 4.2.1 would give $3.1 billion as the desired return on the capital invested in the road system, a figure about $1.0 bn higher than the equivalent PAYGO figure.

On this basis the total costs of the road system are set out in Table 4.3.3.

Table 4.3.3: Estimated breakdown of roading costs by road type 2018/19, Capital return approach

Expenditure type	**Road type**					
	State Highways		**Local roads**		**Total**	
	$m	**Per cent**	**$m**	**Per cent**	**$m**	**Per cent**
Total opns & maintenance (from Table 4.3.2)	***1,001***	***41%***	***1,609***	***49%***	***2,608***	***46%***
Capital return on road infrastructure	1,437	***59%***	1,674	***51%***	3,110	***54%***
Grand total	**2,434**	***100%***	**3,283**	***100%***	**5,717**	***100%***

For the State Highways the identified capital return is similar to the actual capital investment, i.e., $2.4bn v $2.3bn, but for the local road network with its relatively low share of capital expenditure, the difference is more substantial, with actual capital investment of $0.8 bn compared to the target return on capital of $1.7 bn.

4.4 Road vehicle ownership and use charges

4.4.1 Introduction

As has been indicated above road users are required to contribute to the costs of maintaining and operating the road transport network and also contribute through the National Land Transport Fund to the costs of public transport provision in New Zealand. Users are faced with a range of charges and levies the most important of which are:

- Fuel excise duty
- Road user charges
- Vehicle licensing and registration fees
- Regional fuel taxes (Auckland only)
- Vehicle certification and safety inspections
- Driver licensing and testing

In addition to these users are also required to pay:

- levies to ACC on petrol and on motorcycle and other motor vehicle and ownership to cover the costs of road accidents which are met by ACC.
- an Emissions Trading Scheme levy which is used to purchase the carbon credits associated with the consumption of automotive fuels
- a range of other small levies associated with petroleum use.

4.4.2 Fuel duties and levies

The total levies on fuel are set out in Table 4.4.1 below. These include levies raising revenue for Waka Kotahi via the NLTF and levies raising revenues for other agencies.

Table 4.4.1: Average fuel duties and levies 2018/19 (c/litre)

Fuel	Total levy c/litre
Petrol	77.76
Diesel	10.08

Notes (1) These include regional fuel tax at 10c/litre for fuel purchased in Auckland. The figures in this table use the estimated average across the country as a whole.

These can be compared with the average retail costs of fuel (excluding GST) in 2018/19 of 184.5 cents per litre for petrol and 130.5 cents per litre for diesel: these figures represent 42 per cent of the costs of petrol and 8 per cent of the costs of diesel.

Revenues from vehicles using diesel are generated from road user charges which are levied on all vehicles using diesel fuel. While these vary by detailed vehicle class, the average rates by vehicle category are set out in **Error! Reference source not found.**

Table 4.4.2: Average RUC rates by vehicle class ($/km)

Vehicle category	Average RUC rate
Passenger car/van	0.07
Light commercial vehicle	0.07
Medium commercial vehicle	0.10
Heavy vehicle	0.38
Heavy vehicle trailer	0.17

These two sets of levies, fuel duties and RUC, provide the major sources of revenues for the road system.

Fine revenues from users are also fairly substantial at about $190m in 2018/19. However, this revenue is not ring-fenced but goes into the general Government revenues.

4.4.3 Total payments

The estimated total allocation of user payments by payment category and vehicle type in 2018/19 is set out in Table 4.4.3. While there is an overlap between the different types of activities, vehicles have been divided into those used primarily for person transport which in this case is defined to include motorcycles, cars, the lighter LCVs (LCV1) and buses, and those used for the movement of freight which comprise the remainder.

Of the total allocation of the payments to Waka Kotahi/NLTP about 63 per cent are in respect of the lighter vehicles mainly used for person travel and just over a third in respect of vehicles mainly used for freight. Payments to other agencies have a much higher proportion for lighter vehicles reflecting the high shares for ACC levies which are focussed on light vehicles and for the allocation of fine revenues.

Table 4.4.3: Total payments from users allocated by transport use and road type 2018/19 ($m)

	Vehicle used for			**Road type**		
Payment/ Levy	**Person transport**	**Freight transport**	**Total**	**SH**	**Local roads**	**Total**
Payments to Waka Kotahi/NLTP:						
Veh licensing & registration	174	52	226	110	116	226
Fuel duty	1962	0	1,962	928	1,034	1,962
RUC	251	1416	1,667	1,005	662	1,667
Tolls	24	14	39	39	0	39
Other	92	15	108	52	56	108
Total Waka Kotahi/ NLTP	**2503**	**1498**	**4,001**	**2,115**	**1,886**	**4,001**
Per cent of total	*63%*	*37%*	*100%*	*53%*	*47%*	*100%*
Payments to other agencies:						
ACC - license levy	186	49	235	117	118	235
ACC - fuel levy	190	0	190	90	100	190
ETS	240	160	400	208	191	400
RFT	86	58	144	54	89	144
PEFM	18	8	26	13	13	26
LAPT	30	9	39	20	19	39
Maritime search and rescue	13	0	13	6	7	13
Fines	176	16	191	92	100	191
Total other agencies	**938**	**299**	**1,237**	**600**	**637**	**1,237**
Per cent of total	*76%*	*24%*	*100%*	*49%*	*51%*	*100%*
Per cent of total	*66%*	*34%*	*100%*	*52%*	*48%*	*100%*

The allocated split by road type gives broadly similar shares of payments for State Highways and local roads, both for payments to Waka Kotahi/NLTP and to other agencies. For the Waka Kotahi/NLTP payments, this reflects a combination of a high share of road user charges allocated to State Highways, reflecting their relatively high use by heavy vehicles. and the allocation of toll revenues all of which are in respect of State Highways, which are partly offset by a lower share of payments from fuel duty reflecting the higher volumes of light traffic on local roads[9]. Payments to other agencies by road type broadly reflect the higher total distances travelled on local roads.

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[9] The details of these flows are set out above in **Error! Reference source not found.**

4.5 Road users - direct costs

4.5.1 Introduction

Based on a variety of data sets, estimates have been made of the total operating costs associated with a range of different vehicle types. These include:

- Motorcycles
- Cars
- Light, medium and heavy commercial vehicles
- Buses.

In addition to the direct costs of vehicle operation, allowance has been made for the value of time spent travelling. This includes both times spent during the course of work on employers' business (based broadly on wage rates) and also time spent travelling for other purposes. For freight vehicles, the costs are derived from the material supplied by National Road Carriers which allows differentiation of freight vehicle type. For passenger vehicles the values are derived from those set out in the MBCM, appropriately updated to 2018/19 values. An estimate has also been made for the time costs incurred by pedestrians and cyclists. This is based on the values of time set out in the MBCM, although it is recognised that in practice there may be a range of time costs for these active mode trips depending on their purpose. These costs have been divided into those with and without duties. These latter are taken represent the economic costs of travel by vehicle type.

4.5.2 Total road user direct costs

On the basis of the distances travelled and the total numbers of vehicles in each group, the total annual costs of users of the road network for 2018/19 have been determined and these are set out in Table 4.5.1

Table 4.5.1: Estimated aggregate total annual costs by vehicle type (incl time costs 2018/19 ($bn)

Cost type	**Total**	**Person travel**	**Freight travel**	**Pedestrians and cyclists**
Resource vehicle operating costs	42.7	20.5	22.1	
Time costs in working time	35.3	17.6	17.7	
Other time costs	15.6	13.5	0.0	2.1
Total resource costs	93.5	51.7	39.8	2.1
User charges (Duty) (1)	5.0	3.3	1.8	-
Total	98.6	54.9	41.6	2.1

Notes (1) This excludes the costs of fines

This gives an estimated total cost incurred directly by users of the road system of about $99 bn in 2018/19. The economic costs, ignoring the duty, amounted to about $94 bn

The key messages from this include: -

- Person travel, with resource costs of $51.7 bn, accounts for about 55 per cent of the total user expenditure on the roading system. The costs incurred by freight vehicles are smaller at about $40 billion or 43 per cent of the total. The resource costs for pedestrians and cyclists are estimated to account for about 2 per cent of the total
- Of the costs incurred directly by road users, the value of the time spent travelling accounts for 60 per cent of the total resource costs for personal travel but a smaller share of about 44 per cent for freight travel
- The duties and levies paid by road users represent a much smaller share of the total costs amounting to about 5 per cent of the total ($5bn). This share is slightly lower than average for goods vehicles (4 per cent), than for vehicles used for personal travel (about 6 per cent).

The costs incurred directly by road users are put into the context of the total costs of the road system in the following section.

4.6 Total road system costs

The total road system costs are made up of a number of components: -

- Direct road user economic costs. These are discussed above in Section 4.5
- A range of socio-economic costs (as discussed below), which include:
    - Crash and accident costs
    - Greenhouse gas costs
    - Air quality costs
    - Noise costs
    - Ecology costs
- Public sector road system costs
- Costs of parking provision.

These are set out in Table 4.6.1 and summarised in Figure 4.6.1.

The economic costs incurred directly by users, amounting to about $94 bn in 2018/19, account for 76 per cent of the total expenditure on the roading system. The indirect costs of crashes and environmental impacts account for a further 8 per cent.

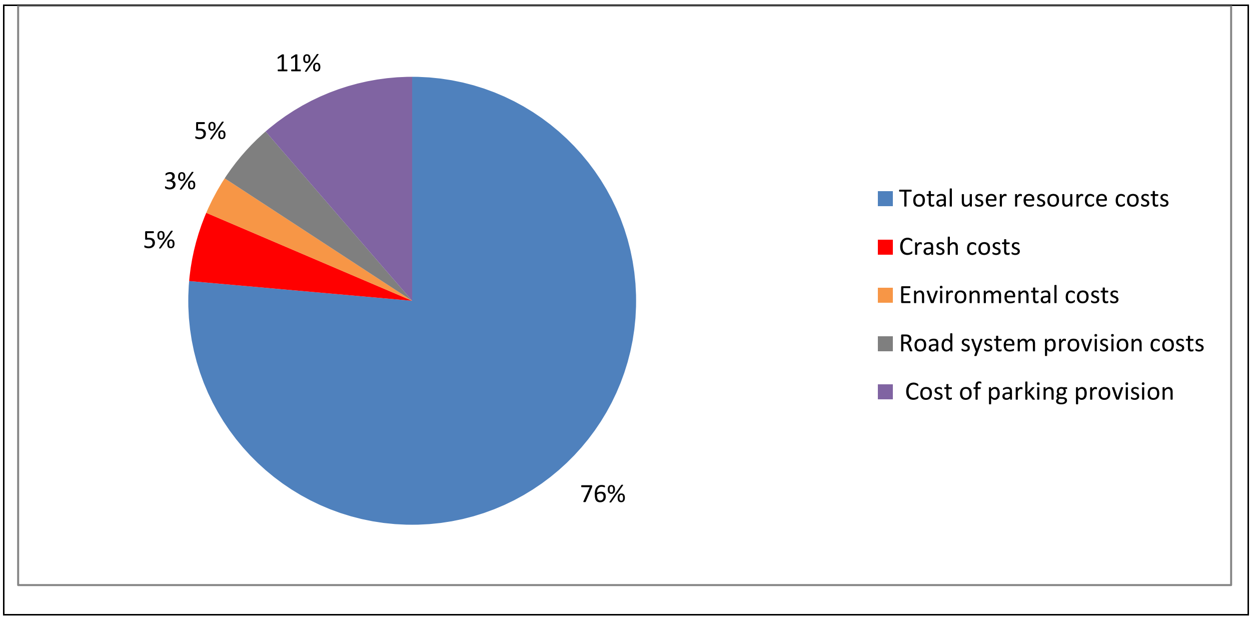
Against these numbers, the costs of providing and operating the road system itself, even on the basis of the desired capital return in place of the lower PAYGO total, are fairly small at about $6 bn or 4.5 per cent of the total costs.

The costs of parking provision are estimated to be substantial at about $14bn or 12 per cent of the total.

Table 4.6.1: Costs of road transport and the road network in New Zealand in 2018/19 ($bn)

	Total	Passenger transport	Freight transport	Pedestrians and cyclists
Costs arising from use of the network				
Costs incurred directly by users (excluding duties and levies)				
Total economic resource costs	93.5	51.7	39.8	2.1
Other social costs imposed by road users				
Crash and accident costs	6.5	4.3	1.0	1.1
GHG costs	1.5	0.9	0.5	-
Air quality	1.1	0.6	0.5	-
Noise	0.9	0.7	0.2	-
Ecology	0.1	0.1	0.0	-
Total	10.1	6.6	2.3	1.1
Total resource costs from use of the road network				
Resource economic costs	103.6	58.3	42.1	3.2
Economic costs of providing and operating the road network				
Capital charge	3.1	2.1	1.0	-
Road renewal	1.0	0.5	0.5	-
Road mtce & operation exc police	1.3	0.9	0.4	-
Police and emergency services	0.4	0.3	0.1	-
Total (incl target return on capital invested)	5.7	3.8	1.9	
Total resource costs for road system provision, operation and use (excluding parking)				
Total resource costs	109.3	61.1	44.0	3.2
Parking provision				
Total costs of parking provision	14.7	14.7	n.a	--
Total system costs including parking				
Total system resource costs	**124.0**	**76.7**	**44.0**	**3.2**

Figure 4.6.1: Total road system economic costs by type (total $124.0 bn pa)



4.7 Balancing user contributions with the costs of the road network

Through a set of levies and duties, road users contributed about $4bn to the National Land Transport Fund in 2018/19, which provided the main source of finance for Waka Kotahi (the details are set out in Table 4.7.1)[10]. Road users also paid a further $1bn to other agencies (excluding any fine revenues).

These revenues from users to the National Land Transport Fund can be compared with the costs of the road system after allowing for the contributions from the Crown and local authorities. Two alternative estimates have been made of these road system costs, one based on the expenditure actually undertaken in 2018/19 as set out in Table 4.7.1, and one based on the charges based on the target rate of return on the roads infrastructure. This is set out below in Table 4.7.2. Against a total cost in 2018/19 based on achieving the target rate of return on the capital invested of 4 per cent of about $5.7 bn, road users contribute about $4bn with the Crown and local authorities a further $1bn, leaving a deficit of about $0.7 bn or about 12 per cent of the costs. On the basis of the allocation of the costs and revenues to passenger and freight vehicles, the majority of this deficit would be allocated to passenger vehicles, for which the deficit amounts to about 16 per cent of the costs of providing the road network. For freight vehicles the deficit is much smaller amounting to just 2 per cent of the allocated costs.

We also examined the allocation of costs and revenues on the basis of the PAYGO system and the results are set out in Table 4.7.2.

With these lower costs, the combined revenues from users, the Crown and local authorities exceed the costs of the road system. This surplus is then used to fund other parts of Waka Kotahi's activities primarily through support for public transport.

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[10] Note that these charges paid by road users (comprising largely FED and RUC) are not included in section 4.6 and table 4.6.1, as they are essentially a contribution towards the costs of developing, maintaining and using the road system.

Table 4.7.1: Costs and revenues for the national road network 2018/19 ($m), Costs estimated on basis of return on capital

	Total	Allocation to:	
		Passenger vehicles	Freight vehicles
Total costs of providing and operating the road system			
Road capital and operating costs based on a 4 per cent return on capital invested.	5,362	3,531	1,832
Policing and emergency services	355	281	73
Total costs	**5,717**	**3,812**	**1,905**
Sources of revenues			
Road users	4001	2503	1498
Local authorities (1)	849	553	296
Crown (1)	199	130	69
Total sources of funding	**5049**	**3185**	**1863**
Surplus/Deficit	-668	-627	-41

Notes (1) Allocated as road capital and operating expenditure

Table 4.7.2: Costs and revenues for the national road network 2018/19 ($m), Costs estimated on basis of PAYGO approach

	Total	Allocation to:	
		Passenger vehicles	Freight vehicles
Total costs of providing and operating the road system			
Road capital and operating costs based on PAYGO approach	4,391	2,860	1,532
Policing and emergency services	355	281	73
Total costs	4,747	3,141	1,605
Sources of revenues			
Road users	4001	2503	1498
Local authorities (1)	849	553	296
Crown (1)	199	130	69
Total sources of funding	**5049**	**3185**	**1863**
Surplus/Deficit	302	45	258

4.8 Road infrastructure Economic Costs (Total and Average)

4.8.1 Overview

This area of work estimated the total and average economic costs by vehicle type for the use of the NZ road infrastructure (state highways and local roads). This involved allocation of infrastructure costs (attributable, joint and common costs) between road user categories based on the characteristics of each vehicle type. This results in a set of fully allocated total and unit costs that will reflect the assessed contribution of each vehicle type to the costs of road infrastructure. They are nevertheless average costs in the sense that the allocated expenditure is summed by cost category and divided by the total output in that category.

4.8.2 Methodology and results

The methodology adopted takes as its starting point that used in MoT's Cost Allocation Model (CAM) to calculate recommended rates for RUC and petrol excise. The CAM rates are set to recover all Waka Kotahi expenditure (on a PAYGO basis) including roads and public transport. CAM includes a road cost allocation matrix that allocates total road costs between five cost 'drivers'. We used this matrix as a starting point to estimate the (fully allocated) average economic costs by vehicle type.

The main issue in calculating average economic costs by vehicle type is the attribution of joint and common costs. CAM provides a rigorous and defensible method of dividing the costs of maintaining and improving the road network between vehicle types in a fair and neutral manner based on the cost causality of each vehicle type. It works by allocating costs to five cost 'drivers' (refer table 4.8.1). This methodology has been reviewed multiple times: while the application of the methodology has been challenged and a number of changes made, the allocation of costs between users appears to be generally accepted.

CAM is used to calculate the contribution required from each vehicle class and hence the charges required to recover the total expenditure on roads in any one year. The basic calculation in CAM allocates the total (state highway plus local roads) budgeted expenditure to the five cost drivers. However, there is no longer a nexus between money collected from motorists and money spent on roads. Additional costs are added to the base rate to pay for non-road expenditure by WK, while roading authorities pay approximately half the cost of WK-approved works on local roads. Since roads are funded on a PAYGO basis, the charges are based on the capital expenditure on road system improvements undertaken in the year in question, rather than any concept of return on assets employed.

To calculate the average ***economic*** costs of the road system, we have taken the CAM analysis, stripped out the road improvement budget items and added in an economic capital charge of 4% of the value of the roading asset. This capital charge was some $3.46 billion (for 2018/19), which is substantially higher than the amount spent in that year on new roads and road improvements ($2.52 billion). A comparison between the CAM rates and rates based on the estimated average economic costs is given in table 4.8.1.

Note that while CAM determines the allocated cost to be recovered from each vehicle type, the actual cost recovery depends on multiple factors. For example, the analysis shows that the CAM price for light vehicles should be seven cents per kilometre. However, for charging purposes, this needs to be converted into a price per litre of petrol, so that the actual cost to each motorist will depend on their vehicle's fuel consumption. The truck rate is derived as an average cost per vehicle kilometre, but this is converted into a charge that depends on the maximum permitted load and the axle configuration. The costs by cost-driver calculated in CAM are used to make this calculation.

If the economic capital charge approach were applied in practice, it would bring the funding calculation more into line with the way roads are treated in each road authority's accounts. Charges would most likely increase for all motorised road users (whether diesel or petrol-powered), and the roads budget would be expected to generate a financial surplus. A potential secondary effect of such a change is that it would result in a slight reduction in overall road traffic volumes with a small switch to other transport modes (particularly the switching of some truck traffic to rail transport). Further analysis would be required (beyond the scope of DTCC) to quantify these likely impacts.

Table 4.8.1 Comparison between CAM rates and average economic costs, 2018/19

Cost driver	CAM rate ($ per 000 km)	Average Economic cost ($ per 000 km)
HV (heavy vehicle km, incl trailers)	$1.19	$0.23
PCE (passenger car unit km)	$10.53	$51.22
GVW (gross vehicle weight km)	$1.56	$3.85
ESA (equivalent standard axle km)	$200.97	$277.27
PV (powered vehicle km)	$43.59	$47.46

4.9 Car Parking

4.9.1 Estimation of NZ parking supply

Based on international data on the numbers of parking spaces provided in major international cities/regions (principally USA, UK and Singapore), the study developed a model for the total number of parking spaces provided (low, medium and high scenarios) related to the number of vehicles owned and the average population density in the region. The resulting model estimates of parking spaces per car, when applied to New Zealand, ranged from 4.1 spaces in urban Auckland up to 4.8 spaces in the rural parts of several regions: on- street parking spaces were estimated to account for some one -third of the total spaces, off-street for two-thirds.

Based on these model estimates, our cost analysis work assumed an average of 4.4 spaces per registered vehicle in NZ, ie a total of 17.2 million spaces. In broad terms, around 40% of these are on-street or within residential property boundaries; and the remaining 60% are either off-street on privately-owned land (usually made available for parking for employees or visitors) or are off-street parking spaces operated on a commercial basis.

4.9.2 Unit costs for parking spaces

Based on multiple NZ data sources, a unit cost model was developed to estimate typical costs of providing and operating parking spaces in NZ, with three cost categories: capital costs; land costs; operations and maintenance costs. The model results are summarised in table 4.9.1.

Table 4.9.1: Unit Annual Costs per NZ Parking Space ($pa/space)

Parking type	Construction costs		Land costs	O&M costs
	Total $	$pa (2)	$pa (1)	$pa
Off-street - surface	2444	147	**	246
Off-street -structure	23,716	1423	**	1464
On-street	1178	71	**	123

Notes: (1) Land costs vary very substantially between situations, especially between urban and rural areas: the typical cost range is from around $2000 pa/space in the Auckland Urban area down to minimal amounts in some of the more rural regions.
(2) The annualised cost figures for construction and land are calculated as 4% (real terms) of the capital values in each case.

4.9.3 Total and average economic costs of NZ car parking supply

Based on the parking supply estimates and the unit costs given above, our central estimate is that the total (economic) cost of parking space provision and operation in NZ is some **$14.7 billion pa**.

Based on the number of light vehicles registered in NZ, this equates to an average of some $3700 pa per light vehicle, or alternatively $3.90 per light vehicle trip.

4.9.4 Marginal costs of parking supply

The study has not undertaken any specific analyses on this topic. However, we provide the following comments:

- The average and marginal costs of parking are likely to converge in the longer term, given the relative scalability of off-street parking. Therefore, average costs are likely to provide a reasonable approximation to long-run marginal costs in most situations.
- This conclusion may not apply to on-street parking, especially in locations where supply is constrained and the opportunity cost of space within the road corridor is high.

4.9.5 Who pays for the costs of parking?

The study analyses of HTS data indicate the following results (averaged over all regions):

- 86% of all trips use off-street parking at their destination,
- 99% of trips do not involve payment of any parking charges, and
- where parking charges are incurred, they are paid by people in the vehicle in 85% of cases.

These results suggest that parking costs are not usually charged directly to drivers, which in turn implies that these costs are either (1) bundled in the costs of goods and services; or (2) paid for indirectly by drivers in other ways (e.g., through local rates); or (3) subsidised by wider society. For example, we expect that the costs of parking at destinations are often subsidised, whereas the costs of parking at people’s homes are likely to be bundled (e.g., into housing costs, for those who park off-street) or partly subsidised (e.g., through rates, for those who park on-street). Data limitations have precluded further investigation of this aspect within the study[11].

The HTS findings together with a broad ‘back of envelope’ assessment leads us to the conclusion that direct user charges for parking spaces in NZ yield annual revenues in the order of $200 -$400 million pa.

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[11] While the NZ Household Travel Survey (HTS) includes questions on parking, these do not (at present) extend to asking about the level of parking fees paid.

This level of revenues would cover between 1.5% and 3.0% of the $14.7 million total annual parking economic costs NZ-wide.

4.10 Road Accidents – Economic Costs and Charges

4.10.1 Background/overview

This section summarises the methodology and analyses undertaken to derive estimates of the Total (Social) Costs, Average Costs, Marginal Costs and Marginal Externality Costs of road transport-related accidents[12] in New Zealand. As well as aggregate cost calculations, the analyses consider the various inter-relationships between the funding and charging for costs related to accidents. This includes the roles of the Accident Compensation Corporation (ACC) and private insurance to cover many of the medical, work-interruption, and property damage costs associated with road accidents and other transport mode accidents (which would otherwise largely be borne by individuals, employers and the public health service).

The section first explores the overall costs associated with road accidents (to both motorised and non-motorised road users) in New Zealand, and the average costs per vehicle-km, net tonne-km or person-km where possible. It then examines the marginal costs and charges (i.e., the unit variable costs of changes to the current transport volumes) and also explores further the payment streams (i.e., who ultimately pays for the costs resulting from transport accidents).

Note that this section covers only accidents occurring on the road system: further details of the topics covered here are set out in DTCC WP D1. Rail accidents (section 5.5 and WP C11.6) and maritime accidents (section 10.4 and WP C14) are covered in separate sections of this report and the supporting working papers

4.10.2 Total and average social costs of motor vehicle accidents

The total annual social costs (in year 2018/19) for road accidents involving motor vehicles (i.e., at least one of the parties recorded in the accident report was a motor vehicle) were $5.65 billion (at June 2019 prices)[13]. Table 4.10.1 provides a breakdown of these costs by user type and road type. The average costs (in cents) per vehicle-km travelled (VKT) and person-km travelled (PKT) are also shown.

It is evident that, in terms of costs "shared"[14], motorcycle accidents involve by far the highest personal risk on a per veh-km or person-km basis, followed by bicycle and pedestrian accidents. The comparisons of costs shared with an allocation based on costs "caused" (i.e., where costs are assigned to the users deemed at fault in the accident) indicate little change in these figures. However, comparisons with costs "suffered" (i.e., where costs are assigned relative to the injury and other costs suffered by each accident participant) reveal that these travel modes have even higher relative costs suffered, mostly offset by reductions in the allocated truck accident costs. On all three cost allocation bases, bus travel (principally in urban areas) appears to be the safest mode, having the lowest costs per person-km.

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[12] For this study, the term "accidents" has been chosen to describe transport incidents that lead to injuries or property damage – this includes on-road "crashes" and also other injury events to active mode users not involving any motor vehicles (for example, it also covers a cyclist slipping on a wet road surface, or a person tripping on a footpath).

[13] Note that this total figure is consistent with the estimate derived by the Ministry of Transport in its most recent assessment (MoT 2020a).

[14] These shared costs represent the result of allocating the total costs for each accident evenly across each road user type involved in the accident.

Table 4.10.1: Total annual costs and average cost rates for road accidents involving motor vehicles – by user type

	Road type	**Bicycle**	**Pedestrian**	**Cars, light commerc'l, other**	**Motorcycle including moped**	**Bus**	**Truck**	**Total**
Costs **shared**[3] ($m/year)	Open (≥80km/h)	26	42	2,809	329	52	317	**3,576**
	Urban (≤70km/h)	85	177	1,539	182	25	62	**2,069**
	All	**110**	**219**	**4,349**	**511**	**77**	**379**	**5,645**
Cost shared per distance travelled by vehicle (c/VKT)	All	35.7	31.0	9.9	123.1	25.5	12.6	**11.6**
Cost shared per distance travelled by person (c/PKT)	All	35.7	31.0	6.3	123.1	2.8	12.6	**7.4**

4.10.3 Total and average social costs of non-motorised road user accidents

For accidents on the road system involving only "non-motorised" users (NMUs), including pedestrians, cyclists, wheelchair users, and users of small-wheeled powered or unpowered devices (skateboards, scooters etc), the following combined data has been obtained, based on the Crash Analysis System (CAS) and ACC datasets. The total social costs of $830 million pa (on a shared costs basis) shown in table 4.10.2 reflect the high number of transport accidents by these modes not captured by Police crash records but reported through hospital and ACC data (e.g., falls).

Table 4.10.2: Parameters and costs for non-motorised road user accidents not involving a motor vehicle

	Total NMU-only
Distance travelled by person (PKT, million kms)	1014
Neutral costs shared ($m/year)	830
Cost shared per distance travelled by person (c/PKT)	82

While the combined risk calculations above suggest an average accident cost per km travelled per active mode user, it should be remembered that walking and cycling also present considerable health benefits from undertaking them (refer section 9.3 of this report), as well as other environmental benefits to society (due to lack of noise, air pollution, severance, etc from walking and cycling), and these benefits are of a similar scale to the accident costs noted above.

4.10.4 Breakdown of accident social cost components

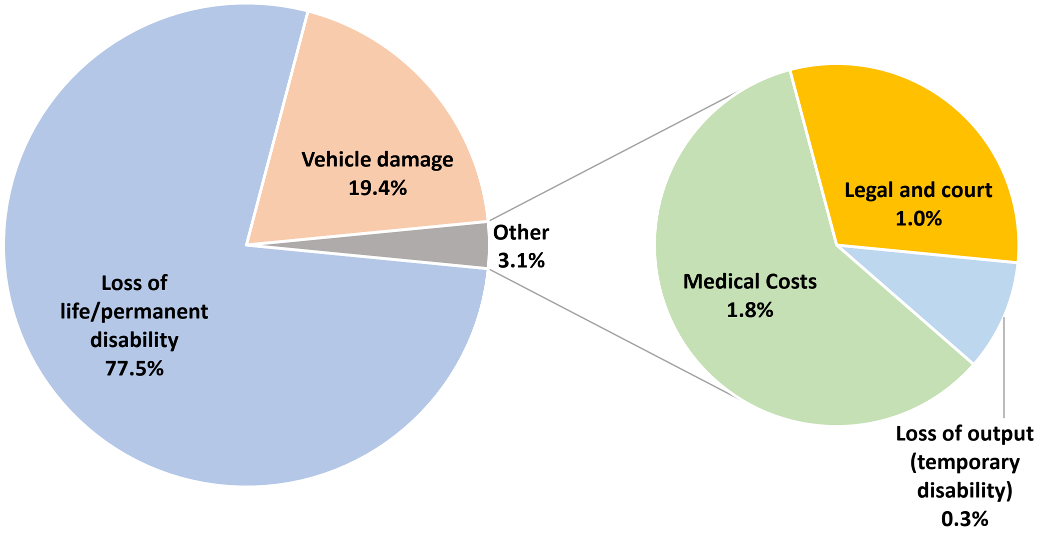
Bringing together the above cost estimates for both motorised and non-motorised road users result in a total annual cost (in 2018/19) of approximately $6.48 billion associated with accidents occurring on the NZ road system.

The social costs of road accidents in New Zealand include components of willingness-to-pay (WTP) to avoid loss of life or permanent disability, loss of productive output through temporary disability (for serious and minor injuries), medical costs, legal and court costs, and vehicle damage costs.

For ***accidents involving motor vehicles***, the WTP to avoid loss of life or permanent disability comprises by far the bulk of the costs, although that is less so for more minor accidents. Other than loss of life or permanent disability, most costs are very small (<2% of total social costs), particularly if non-injury accidents are ignored. Due to the sheer number of non-injury accidents (~250,000 a year), their cost component for vehicle damage is relatively large overall at over 19%.

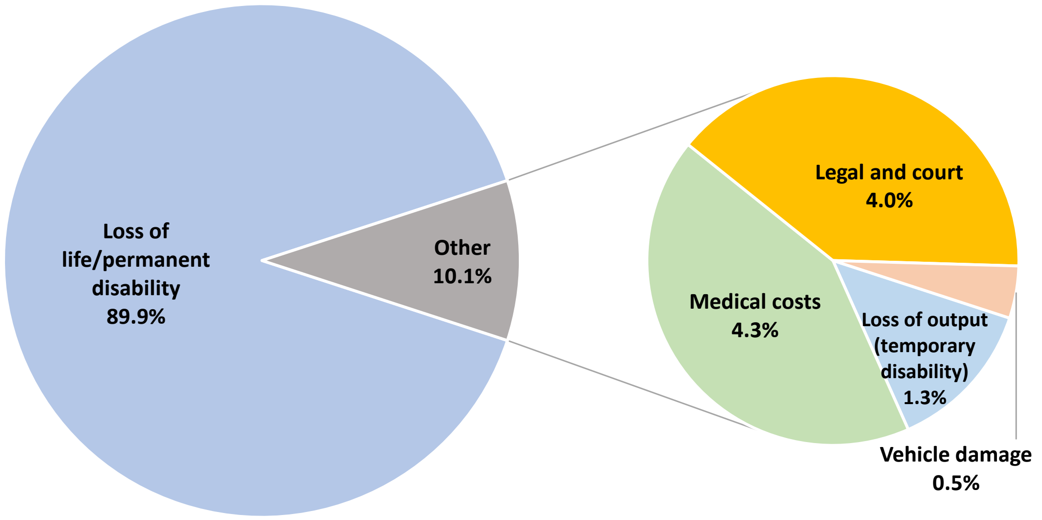
For accidents not involving motor vehicles, the vehicle costs are much smaller, reflecting the high proportion of pedestrian injuries in this group, and the relatively low cost of any damage to bicycles, scooters, etc. The WTP costs of loss of life or permanent disability are now ~90% of the total costs, with the other components all contributing <5% each to the total cost. The breakdown of accident costs by cost category is summarised in Figure 4.10.1 for MV accidents and Figure 4.10.2 for NMU accidents.

Figure 4.10.1: Breakdown of cost components for motor vehicle accidents (by percentage)



For accidents not involving motor vehicles, the vehicle costs are much smaller, reflecting the high proportion of pedestrian injuries in this group, and the relatively low cost of any damage to bicycles, scooters, etc. The WTP costs of loss of life or permanent disability are now ~90% of the total costs, with the other components all contributing <5% each to the total cost. The breakdown of accident costs by cost category is summarised in figure 4.10.1 for MV accidents and figure 4.10.2 for NMU accidents.

Figure 4.10.2: Breakdown of cost components for non-motor vehicle accidents (by percentage)



4.10.5 Marginal costs of motor vehicle accidents

Accident prediction models (where the total vehicle-kilometres travelled VKT by the 'exposed' traffic is the key input) have been used to estimate the number of accidents, with consideration given to the variation in average costs per accident, in three key dimensions:

- Higher ***speeds*** (e.g., on rural roads) are typically associated with more serious injuries (and a greater likelihood of deaths),
- ***Intersections*** involve typically different accident types than mid-block sections, again with different likelihoods of death and serious injury, and

- In ***congested*** situations (e.g., rush hour), traffic speeds are typically slower than at uncongested times, reducing the average accident severity.

Three different types of road environment that contribute to New Zealand’s road accidents have been modelled for motor vehicles:

- Accidents on urban streets (speed limit of 70 km/h and less)
- Accidents on rural roads (speed limit of 80 km/h and more)
- Accidents on limited-access motorways and expressways.

Within urban and rural environments, accidents are further split into those occurring at intersections and those occurring at mid-block sections (all motorway accidents are treated as mid-block, with no at-grade intersections present). Pedestrian and cycle accidents do not have the same level of data breakdown available (e.g., urban vs rural VKT); therefore, for simplification, single-factor models solely based on the active mode VKT have been used for this exercise.

Table 4.10.3 presents the relevant marginal costs for each road environment. These have been derived from the ratio of marginal costs to average accident costs (**MC/AC**). Where applicable, costs for both uncongested and congested situations have been shown separately. Pedestrian marginal costs are presented for all accidents (including those not involving a motor vehicle) and also only for motor vehicle related accidents.

Table 4.10.3: Calculated marginal costs

Sub-model	***MC/AC****	***Marginal costs*** (c/VKT)	***Combined MC*** (c/VKT)
Urban mid-block (uncongested)	1.00 (U)	**13.2**	Urban uncongested **17.3 (U)**
Urban intersection (uncongested)	0.44 (U)	**4.1**	
Urban mid-block (congested)	-1.40 (C)	**-18.4**	Urban congested **-33.1 (C)**
Urban intersection (congested)	-1.56 (C)	**-14.7**	
Rural mid-block (uncongested)	0.80 (U)	**51.3**	Rural uncongested **56.9 (U)**
Rural intersection (uncongested)	0.46 (U)	**5.6**	
Motorway mid-block (uncongested)	1.40 (U)	**5.1**	**5.1 (U)**
Motorway mid-block (congested)	-1.85 (C)	**-6.8**	**-6.8 (C)**
Cycle all (uncongested)	0.20 (U)	**8.1**	**-**
Pedestrian vs MV (uncongested)	0.40 (U)	**12.4**	
Pedestrian only (uncongested)	0.40 (U)	**46.2**	

Key: * (U) = uncongested, (C) = congested

The results illustrate the congestion effects in urban and motorway environments where the relative increase in accident numbers with VKT increase is dampened by the reduced cost per accident due to lower traffic speeds. The negative marginal cost estimates for urban congested situations indicate that, in such situations, increases in traffic volumes, typically resulting in reduced traffic speeds, also result in reduced total accident costs (although maybe more accidents in total). While the relative contributions of mid-block and intersection accidents are fairly even in urban environments, mid-block accidents contribute far more in the rural environment, reflecting the relative sparsity of intersections.

Note that the VKT values for cycle and pedestrian marginal costs refer to an additional veh-km of these modes, e.g., what is the relative marginal cost from an additional kilometre cycled or walked. The findings illustrate the considerable cost suffered by pedestrians from accidents *not* involving motor vehicles (i.e., “slip, trip and fall” accidents).

4.10.6 Charges and revenues

A qualitative exploration of relevant costs and charges relating to motor vehicle accidents in New Zealand was undertaken. This exploration has identified the role of various financial streams, including ACC levies, health/life/vehicle insurance, public taxes and other personal costs. Some of these costs and charges are essentially “internalised” by the road user (i.e., they have to pay for them directly, which may affect their safety behaviour) while others are external to the road user and are typically borne by society in general (e.g., through general taxation).

A comparison of ACC charges received and claims paid out of the Motor Vehicle account (roughly $450 million per year) show that motorcycles and (to a much lesser degree) buses continue to under-fund their relative accident treatment costs from ACC. Cars and other light commercial vehicles slightly over-pay, whereas trucks appear to also over-pay relative to their ACC claims paid out. These figures do not include the ACC payments (roughly $70 million per year) from the Motor Vehicle account for injuries to non-motorised users (e.g., pedestrians and cyclists), who do not pay anything directly into this account. Some costs associated with non-motorised users who injure themselves away from motor traffic also come out of other ACC accounts; in particular, the “Place of Sports & Recreation” account.

4.11 Road Infrastructure-Marginal Costs

4.11.1 Overview

This section addresses the marginal costs of road maintenance and rehabilitation arising from road use. It outlines methodologies and provides estimates for social, short run and long run marginal costs (as defined below). The average (fully allocated) costs are addressed in a separate section (4.8).

Heavy vehicles impose costs on all other vehicles (externalities) resulting from their impact on the pavement structure, affecting ride quality and vehicle operating costs. These costs depend on the axle load, the remaining strength of the pavement and the volume and mix of other traffic: they continue until such time as the road is repaired.

4.11.2 Marginal cost concepts

Three marginal costing concepts were essential to our work:

- ***Social marginal costs (SMC***) - refers to the impacts of other traffic on vehicle operating costs (VOC) in the absence of intervention by the road agency. This is a short run externality cost, reflecting the ‘without intervention’ case and continuing until the road is repaired/rehabilitated.
- ***Short run marginal costs (SRMC)*** - refers to the additional agency cost involved in mitigating the road wear by restoring the road to its original condition (i.e., the ‘with intervention’ case). It

also includes the externality costs imposed on other traffic prior to implementing mitigation measures.

- ***Long run marginal costs (LRMC)*** - refers to the additional costs of constructing a stronger road to better accommodate additional traffic. Given the substantial economies of scale in road construction, it always appears better to cater for expected increased traffic by building thicker pavement initially.

We define two “short run” cost concepts and one “long run” measure. We estimate ***social marginal cost (SMC)*** as the impact on the vehicle operating costs (VOC) of other traffic in the absence of intervention by the road agency. This cost is an externality that persists until the road is repaired[15]. We use the conventional definition of the ***short run marginal cost (SRMC)*** as the additional agency cost required to mitigate the road wear, but also include the externality costs imposed on other traffic pending road maintenance. ***Long run marginal costs (LRMC)*** are the additional costs of building a stronger road to better accommodate additional traffic. There are big economies of scale in road construction such that it appears to always be better to cater for increased traffic by building thicker pavement initially.

4.11.3 Methodology

The social marginal costs (SMC) and short run marginal costs (SMRC) were estimated by applying the principles and methodology incorporated in the World Bank Highway Development and Maintenance Model (HDM-4). The relationships have been adapted/calibrated to New Zealand conditions and incorporated in the Deighton Total Infrastructure Management System (dTIMS) model framework used by (or on behalf of) New Zealand’s national and local road agencies. The road database used is a sample of some 6,000 road sections of New Zealand state highway, rural and urban local authority roads.

Because the effect of one additional vehicle is very small (but then multiplied by many vehicles), the analyses were undertaken for increases in steps of 5% of heavy and medium commercial vehicles[16]. Using these data to estimate the effect of one vehicle requires a linearity assumption that may be taken as an appropriate approximation, on the basis that changes of this (5%) order are likely to be of most interest in policy analysis.

Long run marginal costs (LRMC) were calculated using an estimated relationship between road strength and pavement life. This was used to estimate the extra pavement thickness and thus the cost to cater for the marginal vehicle.

The impact of additional traffic depends on the initial condition of the road (always used as the baseline) and the volume of traffic. Estimates of the marginal cost were made for eight classes of road – urban or rural, light or heavy traffic, and rough or smooth condition. The analyses were undertaken to cover a 10-year period.

4.11.4 Results and comments

The social marginal cost (SMC) defined above is the ‘roughness’ cost imposed on all subsequent vehicles using the road: it thus depends on how long the road is left before the surface is rehabilitated. If we were to limit the calculation to increased VOC in the year the additional traffic occurs, the SMC for rough roads is similar for all road types, all varying between $1.30 and $1.80 per equivalent standard

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[15] It is not the only externality from road use: other externalities such as congestion, road safety and environment are discussed in other sections of this report.

[16] It is assumed that the contribution of light vehicles to overall road wear is negligible.

axle -kilometre (ESA-km). The SMC for smooth roads (i.e., roads with IRI less than 3) is significantly lower, at $0.14 and $0.23 for low volume urban and rural roads respectively, and $1.19 and $0.49 for high volume urban and rural roads.

The SRMC is the additional cost of restoring the pavement to its original condition in response to the additional traffic. The main impact of additional traffic is to bring forward pavement repair/ rehabilitation work. The wear caused by the additional traffic results in increased vehicle operating costs, but this is partially offset by a reduction in the costs for existing traffic as the time till repair/ rehabilitation is reduced. These costs will be very situation-specific and be influenced by the sample of roads used in the analysis. For rural roads, the estimated SRMC is less than the SMC, while for urban roads it is 2-3 times higher, consistent with a 5-year rehabilitation programme. Again, the marginal cost is significantly lower for smooth roads.

The LRMC as defined above is the cost of adding road strength (e.g., pavement depth) to cater for additional traffic volumes. Significant economies of scale occur in terms of pavement life, so much so that the LRMC varies from $0.06 per ESA-km for rural high-volume roads (state highways with high truck numbers) to $1.82 for low volume urban roads with very low truck volumes.

Both the SMC and the SRMC are higher than the estimated road user charge (RUC) per ESA. However, the marginal costs for rural roads are of similar order to the RUC. The LRMC for rural low-volume and for urban high-volume roads are in the same range as the RUC charges.

4.12 Costs of Congestion

4.12.1 Overview

This section addresses road congestion costs, which arise due to the interaction between vehicles. These costs have been addressed through three analytical approaches, using different data sets:

(A). At the local level, traffic speed and density observations were analysed at a number of sites across New Zealand to determine the relationships between traffic speed, density and flow,

(B). Data from the Auckland, Wellington and Christchurch regional transport models were used to estimate the average costs of congestion in those cities[17], and

(C). Road construction costs from recent and proposed road capacity expansion works in NZ were used to estimate the costs of increasing the capacity of a road to cater for increases in demand and so reducing congestion levels.

The basic principles underlying traffic congestion, including an understanding of the fundamental diagram of traffic whereby too many vehicles attempting to use a road actually reduce its carrying capacity, have been known for many years (e.g., Greenshields 1935). There is a large volume of literature on the subject, mostly in terms of optimum congestion charging. The economist’s rule for pricing is to price equal to the externality. This is a short run marginal cost (SRMC) concept – it varies by time of day and its purpose is to ensure that the existing infrastructure is used efficiently. The long run

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[17] These models are not ideal. There is some concern that the Household Travel Survey data underpinning these models is very old and the strategic models use simplistic volume-delay curves that generally do not account for intersection delay. The delay induced by ramp metering and onramp merges will also be missing. Alternate data sources are discussed in WP D2.

marginal cost is the cost of expanding the road to cater for the marginal vehicle. The investment rule is then to increase capacity if the long run cost is less than the short run cost. This is mathematically the same as saying invest if the benefit: cost ratio for increases in capacity exceeds 1.0. Note that the costs and benefits are very situation-specific – while the long and short run costs estimated in this study are indicative, any actual road improvement would require a full cost: benefit analysis.

4.12.2 Approach (A): Analysis of traffic speed, density and flow relationships (site-specific)

4.12.2.1 Scope and methodology

It is possible to derive the social marginal cost on a road section by using the travel time and the free flow time to calculate the elasticity of speed with respect to traffic density (Yang et al 2019). Previous analysis of congestion in New Zealand (Wallis and Lupton 2013) indicated that the relationship between travel time and demand could be represented by a BPR function[18]. We therefore used data on traffic volumes and speeds collected on a number of urban roads across both islands to see if we could fit a BPR function to the data. This would enable us to estimate the externality by time of day. Only sites that become congested at some stage during a typical day were studied.

In most cases, a BPR function (refer WP D2 for details) provides a satisfactory fit to the observed data, relating traffic speeds to vehicle density on the road. In some lower traffic urban situations, the observed trips formed a completely different pattern, and a hyperbolic-shaped function was required to fit the data. It appears that the hyperbolic function arises due to the effects of side friction and delay at signalised intersections: in this case, the relationship is probably not strictly causal, but the result of higher levels of pedestrian and other activities coinciding with periods of higher traffic volumes.

The main source of data used was GPS data from vehicle navigation systems: more than 10 years of speed data on roads throughout New Zealand are available. These data were used to provide speed and number of probes (GPS units from which data are collected) by time period for fifteen roads. Most locations provided data for three separate points on the road in each direction. Data were extracted for a ten-week period during the third school term of 2019. The data were plotted and a curve that best fitted in terms of maximum speed and maximum flow was fitted in each case.

4.12.2.2 Results and interpretation

The results from the individual road sections are very site-specific, with the short run marginal cost ranging from zero (Waimakariri bridge northbound) to $1.85/km (Dominion Road northbound). The corresponding implied annual cost of congestion averaged some $1 million per kilometre over the chosen sites but ranged up to $7 million per kilometre.

Some of the results may appear a little surprising, for example the low externality attributed to State Highway 1 (now SH59) between Pukerua Bay and Paekakariki. This is most likely due to bottlenecks that restricted the traffic at each end of this stretch, and the 80km/h speed limit: this means that the free-flow speed and the speed at capacity are virtually the same, while the demand is never able to exceed capacity.

While some urban streets exhibit BPR-type congestion, others exhibit a hyperbolic relationship where speeds appear to be constrained by side friction and signalised intersections. While it would be possible

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[18] This relationship was originally proposed by the US Bureau of Public Roads (BPR 1964).

to estimate the underlying relationship, it is probably not causal. The SRMC will only be significant towards the tail of the distribution where the road is approaching capacity.

4.12.3 Approach (B): Average costs of congestion – Auckland, Wellington and Christchurch regional transport model analyses

4.12.3.1 Scope and methodology

In order to get some measure of the overall average costs of congestion we need to look at entire journeys at a network level. Data from the Auckland, Wellington and Christchurch transport models were used to estimate the total congestion costs and the average cost per kilometre in the three metropolitan areas. The results for Auckland were also compared with those calculated in previous studies.

Cities tend to form around a city centre as this maximises accessibility of people to employment, business and commerce. The effect of congestion is to increase the cost of travel, in particular the cost to the centre: this warps the time vs distance plane, increasing the relative attractiveness of non-central locations. We ranked the zones in each city under both free-flow and congested speeds and plotted the difference to show the impact of congestion on location attractiveness. This is most noticeable for Auckland, where the effect is to move the centre of attractiveness southward but is also apparent for Wellington and Christchurch.

4.12.3.2 Results and interpretation

The average congestion costs per kilometre faced by motorists in the three metropolitan areas were estimated using each region’s transport model, with the results shown in Table 4.12.1. A limitation of this approach is that the transport models effectively assume a uniform ‘peak’ demand over a two-hour period: this is likely to under-estimate the actual delays. The average delay costs during the AM peak period vary from $0.08 per kilometre for Christchurch to $0.31 per kilometre for Auckland, while the long run marginal cost based on recent projects in each centre was a factor of 10 higher, at $0.80 per pcu-km in Christchurch, $3.20 in Wellington and $3.10 in Auckland (refer approach (C) below). The total delay per AM peak period for Auckland is $1.7 million per day, equivalent to $850 million per year, while the ‘avoidable’ cost of congestion[19] is $400 million per year. This compares with the figure of $145 million calculated by Wallis and Lupton in 2013, which equates to $155 million in 2019 prices.

Table 4.12.1: Average delays and costs (regional transport model results)

	AM peak trips	Free flow time (minutes)	Actual time (minutes)	Distance vehicle km	Delay per AM peak	Delay cost per kilometre	Annual Cost of Congestion
Auckland	543,500	6,164,000	9,366,500	5,776,000	$1,730,000	$0.31	$400 million
Wellington	182,700	1,738,000	2,189,000	1,178,000	$243,000	$0.21	$39 million
Christchurch	226,000	2,260,000	2,723,000	1,810,000	$250,000	$0.14	$4 million

Source: consultant estimates.

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[19] I.e., comparing with the speed at capacity rather than the speed at free-flow.

The average delay per kilometre is not very helpful as the cost varies so significantly across the network. However, in the case of Auckland, a group of government officials from six agencies have considered “The Congestion Question”: one of the options assessed was a cordon charge for entering the Auckland CBD. Based on our analysis we calculate that about 5% of all AM peak trips are responsible for 14% of the congestion delays currently across this cordon. The average delay for these trips is 15 minutes and the short run marginal cost is $33 per trip. This means that the marginal vehicle dissuaded from travelling at the peak would initially reduce total network delay costs by $33. However, if a charge were to be introduced, the effect of the charge would be to reduce demand at the peak. We estimate that the equilibrium SRMC and thus the price that would result in the peak demand for travel just equalling the road capacity across the cordon would be $7.70 per trip. (Note however that the COVID situation and post-COVID adjustments may reduce the demand – and hence the price - for CBD-oriented trips, at least in the shorter term.)

4.12.4 Approach (C): Costs of increasing traffic capacity (long run marginal costs)

4.12.4.1 Scope and methodology

Congestion is a short run marginal cost. The long run marginal cost is the cost of increasing the capacity of the road by one unit. Road construction involves lumpy investments, so this concept has practical issues. WK provided data on the capital costs of recent road capacity increases: this was divided by the expected increase in peak period capacity in order to provide an estimated marginal cost. Details of a sample of in the order of 15 -20 NZ state highway schemes in the Auckland, Hamilton, Wellington and Christchurch areas that were completed within the last 10 years or so, or that are under construction or in an advanced state of planning, were provided by WK. An average lane capacity was used to estimate the cost per additional passenger car unit (pcu) of capacity.

4.12.4.2 Results and interpretation

The sample of highway schemes provided by WK was reduced to 12 schemes that were ‘normal’ in terms of costs/lane km (by omitting some very high-cost schemes involving tunnelling or elevated sections). The average costs for the ‘normal’ schemes were $23m/lane km for Auckland, Waikato and Wellington, and $6/lane km for Canterbury. These costs were translated into annual costs per pcu-km, giving figures of $3.20 for Waikato and Wellington, $3.10 for Auckland and $0.80 for Canterbury. Since additional capacity is primarily required for the peak periods, these figures were then translated into marginal costs per peak pcu-km.

The standard rule to determine whether infrastructure investment is optimal is that the short-run marginal cost (SRMC), which is the cost imposed by the marginal user without adjusting capacity, must equal or exceed the long-run marginal cost (LRMC), which is the cost of adjusting capacity for the marginal user. Our analyses indicated that in most cases SRMC was less than LRMC: however, there were some situations in Auckland where the SRMC exceeds the LRMC, such that capacity expansion could be justified on economic grounds.

We note that these analyses are at an abstract and generalised level. A real network contains many links each with differing demands, while practical considerations limit the design opportunities – investments are lumpy and often indivisible. Actual investment decisions should be based on scheme-specific cost-benefit analysis, which can take these and other factors into account.

Chapter 5: Rail System Appraisal

5.1 Coverage of chapter

The New Zealand rail system is used for the movement of freight, long-distance passengers, and urban passengers. Urban passenger transport is covered in a separate chapter, so this one is about freight and long-distance passenger only.[20] The major activity is movement of freight, along with three long distance tourism services and two[21] inter-regional passenger services. Heritage operations access parts of the network from time to time, but their network usage is minimal and is not covered here.

The report covers operating costs for both networks and train operation, their maintenance, and the associated capital assets. It includes rail safety, but not other externalities such as emissions and noise (These are covered for the transport sector as a whole in separate chapters, with a summary in Table 5.6).

The Cook Strait ferries are covered in a separate chapter, although the costs of moving rail freight on them is included in the costs discussed in this chapter.

5.2 Overview of rail system ownership, structure, management and funding arrangements

5.2.1 Sector organisation

KiwiRail Holdings Ltd is the overall holding company for the Crown's rail business (other than the basic land ownership). It is a State-Owned Enterprise ("SOE".) KiwiRail covers both above (freight and long-distance passenger) and below rail activities in an integrated way. It is the only rail freight operator but competes in the overall freight market.

The New Zealand Railways Corporation ("NZRC") holds approximately 18,000 ha[22] of railway land on behalf of the Crown, for the benefit of KiwiRail. That land is leased to KiwiRail.[23] NZRC is a statutory corporation and is also covered by the State-Owned Enterprises Act 1986.

Auckland Transport and Greater Wellington Regional Council own rolling stock, set urban passenger rail policy, and appoint contract operators for metro trains and others (manufacturers) for their maintenance. KiwiRail continues to own and maintain the below rail infrastructure in metro areas:[24] AT and GWRC pay their share of the maintenance costs of this infrastructure through contracts with KiwiRail. GWRC owns 83 electric multiple units ("EMUs") and 25 locomotive-hauled passenger vehicles, and AT owns 72 electric multiple units and eight diesel units.

Apart from KiwiRail and the operators and train maintenance providers in the two metro areas, most of the 82 licenced rail operators are small in scale. This chapter's rail coverage is concerned with KiwiRail, principally as a freight organisation.

5.2.2 Asset ownership and oversight

The shares in KiwiRail Holdings are owned by the Minister of Finance and Minister for SOEs. They exercise oversight through the appointment of an independent Board of directors and regular

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[20] This study is concerned with the active rail network. Parts of the network are disused by the national rail operator, although some of these are used by tourist ventures using electric carts or by heritage railways. These are not covered by this report.

[21] The second, the "Te Huia" Hamilton - Auckland, train, was introduced after 2018/19 and is not covered by this chapter.

[22] New Zealand Railways Corporation (treasury.govt.nz)

[23] NZ Railways Corporation, Annual Report 2019.

[24] "Below rail" includes track and other infrastructure, including signalling and train control, electrical traction equipment, and station platforms. "Above rail" is the operation of trains and associated activities.

performance reporting. Shareholding Ministers influence the strategic direction of the company through regular letters of expectation, being consulted on material transactions, providing commercial investments, and providing feedback on Statements of Corporate Intent. Shareholding Ministers may purchase goods and services from any SOE, with KiwiRail currently providing domestic wagon assembly and EF electric locomotive fleet refurbishment services to shareholders under this arrangement[25]. Shareholding Ministers receive advice from the Treasury on the commercial performance of all SOEs,

There is further oversight through parliamentary reviews of performance (currently through the Transport and Infrastructure Committee). Audit NZ advises that committee and suggests lines of inquiry, which can be wider in scope than simply reflecting the Statement of Corporate Intent targets. The Ministry of Transport has a policy role e.g., in terms of reviewing funding for rail, and preparing the non-statutory annual rail plan, and being responsible for preparing and advising on transport legislation.

Under the Land Transport (Rail) Legislation Act 2020, KiwiRail now has a statutory obligation to prepare a Rail Network Investment Programme, “RNIP”. The RNIP responds to the Government’s strategy for rail, outlined in the New Zealand Rail Plan (aligned with the Government Policy Statement on Land Transport). The RNIP is subject to Waka Kotahi advice and to Ministerial approval. It is part of the mechanisms for wider public funding of rail. Above and below rail activities continue to be run by KiwiRail as an integrated business, but with separated accounting.

The Land Transport Management Act 2003 covers the mandatory Public Transport Operating Model (PTOM), which requires rail services operated by AT and GWRC to be contracted.

There is no obligation on KiwiRail to maintain any of the services it operates,[26] nor to continue to use particular lines. Closure of a line however requires ministerial approval.[27] Cessation of urban services is at the discretion of the regional council and is subject to local political control.

5.2.3 Sector regulation

Safety

The Railways Act 2005 sets out a suite of controls on railways aimed at safety. It also contains provisions for the protection of railways from external interference. It focuses on the systems used by rail operators and by rail access providers, rather than the driver focus of road transport rules. The primary obligation is to ensure, so far as is reasonably practicable, that the railway is safe in terms of having no deaths or serious injuries. The definition of reasonably practicable is the same as that in the Health and Safety at Work Act 2015 (which also applies to rail).

The Railways Act also provides for priority for trains at level crossings,[28] and related provisions, e.g liability and responsibility for maintenance of crossings. There are further provisions about level crossings in the Land Transport Act[29] and the Land Transport (Road User) Rule.[30] The impact of all these is to give right of way to the train and oblige road vehicles to give way to rail vehicles. Rail is also subject to the Transport Accident Investigation Commission, which makes reports on selected rail accidents, including “near misses”. These recommendations are taken up, and KiwiRail’s reaction to them monitored, by Waka Kotahi.

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[25] State Owned Enterprises Act 1986, s 7.
[26] Apart from those subject to a funding agreement.
[27] New Zealand Railways Corporation Act 1981, s 14(3)
[28] Railways Act, s 80.
[29] Land Transport Act 1998, s 213A.
[30] Land Transport (Road User) Rule 2004, Part 9.

Access

KiwiRail Networks manages access to the national rail system for new and existing users. Access management is required given the rail network is shared by freight and passenger services, to ensure all services and maintenance operations have fair access to the network.

Access is provided to rail users who hold a Rail Network Access Agreement with KiwiRail (as network owner) and a rail licence with Waka Kotahi (as rail safety regulator). There are eight access agreements between KiwiRail and rail operators, and all parties (including KiwiRail) are subject to Common Access Terms. Timetable committees operate in the metro networks to perform the duties and obligations conferred under the Common Access Terms, such as approving blocks of line for maintenance and scheduling passenger services.

Prices for rail activities, above or below rail, are not specifically regulated in New Zealand. Regulation of competition and access on rail relies on the general provisions of the Commerce Act 1986.

The new funding arrangements, include a track user charge for freight, broadly comparable in concept to the track access charges in Europe. The track user charge is paid to the National Land Transport Fund by KiwiRail freight revenues to compensate for the wear-out costs of its freight services by using the network. Regional Councils with network agreements have access to the track, and pay for the track usage for urban trains, on a negotiated, full cost recovery basis. The agreements give the councils greater say in the management of the infrastructure assets in urban areas. There is no government regulation of this process, although network funding should enable safe rail outcomes by those parties with rail safety licences. As well, a substantial part of the funding comes from the National Land Transport Fund through the RNIP, so the government can influence the process, through the triennial Government Policy Statement on transport, or more directly.

There appears to be more demand for alternative operators in the passenger market than the freight market. While there is no statutory access regime for rail (unlike in some other countries), KiwiRail contracts access rights to other operators provided they comply with safety rules, e.g., Dunedin Railways, heritage groups and similar bodies, and metro operators in Auckland and Wellington.

Environment

Road, rail, and airports (but not seaports) have requiring authority status under the Resource Management Act,[31] and so can use the RMA designation process. This enables planning for capital works, but also effectively gives consent to carry out normal operations on the designated land, operations that might otherwise require a resource consent (at the district level; resource consents are still required for regional plan issues).[32]

5.2.4 Funding

KiwiRail spent about $1.1 billion during the 2018/19 year, mostly on operating costs ($621m) and capital investments ($469m). Outside the metros and other grants, the capital was spent mainly on the network ($119m) and rolling stock ($94m).

Of the spending, $687m was funded by its customers. Of this, $61m was from infrastructure customers, mainly the metros. Other substantial contributions were from freight ($403m) and Interislander ($138m) customers.

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[31] A requiring authority can essentially tell a local body that it requires land to be designated for its work or project. Resource Management Act 1991 (RMA), s 168.

[32] RMA, s 176.

A large contribution, $315m, was received from its shareholder, the Crown, as an equity injection. A further $94 million was received from government agencies and local bodies for particular projects.

5.2.5 Land

As at 30 June 2019 the "rail network corridor" land, owned the NZRC, was valued at $3,516m.[33] This is in fact the value of all land owned by NZRC and leased to Kiwirail (long term, exclusively and for only nominal consideration), which includes yards and other land not strictly "corridor" land in the sense of a right of way between places. Land is valued on the "adjacent use" basis (i.e, across the fence).[34]

The valuation has been adjusted to remove non-rail use land. On an interpolated basis[35] the value of land related to rail activities on active lines is $2,897M for 2019. Of this, land used for urban passenger transport is estimated at $1,389M, after adjusting for freight (and long-distance passenger) joint use. Land for freight and long-distance passenger use is estimated at $1,508M.

5.2.6 Network now covered by National Land Transport Fund

Under recent legislation,[36] a new funding mechanism and stream has been added for KiwiRail. This followed the Future of Rail review and enables funding for infrastructure through the NLTF. The network operations are vertically integrated but are separately accounted for to reflect the public-benefit function of the network and the profit-oriented function of the above rail businesses. KiwiRail reports on these functions separately to maintain transparency in its funded outcomes for the benefit of the public.

As part of the scheme, KiwiRail (on behalf of users) and any other freight users of the National Rail System will have to pay a Track User Charge (TUC). The possibility of direct funding from the government remains open.

The TUC is based on the variable costs of providing the infrastructure, and is charged per gross tonne kilometre, including the weight of the locomotives. KiwiRail estimates its total variable infrastructure costs at $53m pa,[37] but it is intended to phase the charge in over time. The level of the charge for the first three years has been set and will recover about 40% of variable costs by the third year; the remaining years are still subject to further review.[38] For 2021/22 the charge is $1.18 per 1000 leading gross tonne kilometres.[39]; $1.65 for 2022/23, and $2.11 for 2023/24 and beyond,[40] subject to review. How much it raises will depend on traffic levels, but on the 2018/19 level of 9.959 billion gtkm used as a base,[41] it should raise $11.7M, $16.3M, and $20.9M respectively.[42]

The aim of the new legislation is to give effect to the Rail Plan, through access to the NLTF and the publication of an annual Rail Network Investment Programme. That programme covers all "below rail" expenditure. Over the next 10 years, KiwiRail estimate that a sum of $444m (a year,[43] excluding metro

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[33] NZ Government, "Financial Statements of the Government of New Zealand for the year ended 30 June 2019" AJHR B11, Note 16, p 87. The last valuation before 2019 was as at 30 June 2017. See NZ Railways Corporation *Annual Report 2017,* Note 5, p 19. The next revaluation was at 30 June 2020 and added $259m to the value. See NZRC, *Annual Report 2020*, Note 5, p 18.

[34] NZ Railways Corporation *Annual Report 2019* (AJHR F 18), p 4, Note 1(a), p 14 and Note 5, p 17.

[35] Between the two dates the land was revalued (2020 and 2017), on the basis that 2019 is 2017 plus 2/3 of the 2020-2017 difference.

[36] Land Transport (Rail) Legislation Act 2020, now part of the Land Transport Management Act 2003.

[37] Cabinet paper "The Future of Rail: Railtrack User Charges" June 2021, para 25, p 4. (www.transport.govt.nz)

[38] Cabinet paper, above n 18, para 46, p 6.

[39] "Leading" tonne km include the weight of the locomotive.

[40] Land Transport (Railway Track User Charges) Regulations 2021, reg 9.

[41] "Rail Track User Charge Phase 2 Cost Recovery Impact Statement" (CRIS-2), p 7, footnote 6 (www.transport.govt.nz).

[42] Cabinet paper, above n 18, Table1, p 7.

[43] Includes inflation, train control, insurance, and overheads

costs and revenues, and miscellaneous revenue) would cover operating and capital requirements of a "resilient and reliable" railway, the scenario chosen by the government that underlies the Rail Plan.

5.3 NZ rail network, services and usage overview

5.3.1 Key rail statistics.

KiwiRail owns and operates 3500 route km of track, 258 locomotives, and 4605 wagons. Another 300 km (mostly owned by KiwiRail) is operated by heritage operators or tourism ventures. Freight is handled between train and road at 17 "Container Transfer" sites at places ranging in size from Auckland and Christchurch to Ashburton and Oamaru.

Rolling stock is maintained at one workshop (Hutt) with another being redeveloped (Hillsde, Dunedin), and depots at Auckland, Hamilton, Mt Maunganui, Kawerau, Palmerston North, Wellington, Picton, Westport, Christchurch, and Invercargill.

5.3.2 Key traffic statistics

Overall, the rail business carried 20m tonnes in 2018/19, and generated 4,407 million net tonne km, including third party container tares (and miscellaneous traffic outside the main market segments in Table 5.1). The average haul was thus 220 km. It earned $402.7M in freight revenue. Average revenue per net tonne kilometre for freight was thus 9.1 cents Without third party container tares there were 17.3M tonnes and 3,847M ntkm.

The business also generated 8,605 million trailing gross tonne km,[44] giving a cost of 4.7 cents per gtkm (including networks). There were 9.58 million freight train km run, and 241 million wagon km, giving an average train load of 25 wagons and 460 tonnes net with third party container tares, 402 tonnes without (898 tonnes gross). The ratio of net tonne km (including 3rd party containers) to gross tonne km was 51% and without the container tares, 45%. Further detail is in Table 5.1.[45]

Most traffic (by tonnes) moves in the "Golden Triangle" area Auckland – Waikato – Bay of Plenty.[46]

Table 5,1 Key freight statistics

Item	IMEX*	Domestic	Bulk	Forestry	Total	Total incl miscellaneous
Tonnes, millions, freight only	7.9	1.6	2.8	4.8	17.1	17.3
Ntkm, millions, freight only	1473.5	917.4	738.8	683.5	3813.1	3847.0
Ntkm, millions, incl 3rd party containers; and generators	1888.1	1031.8	753.0	688.2	4361.1	4407.4

Source: WP C11.5, Table 2. Excludes other, miscellaneous traffic. *Import-export traffic in containers.

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[44] Gross tonne km throughout this paper, apart from the TUC calculation, are "trailing" gtkm, i.e., they exclude the weight of the locomotive. This is the normal way of calculating gtkm. The TUC calculation included the locomotive weight.

[45] The costs include an internal transfer for the costs of carrying rail on the ferries. This is included at the rate prevailing in 2018/19. With the new ferries now ordered, this is expected to reduce.

[46] FIGS has information on origin-destination by region. Freight and logistics | Ministry of Transport

The data indicates the key role rail plays in handling import and export traffic in New Zealand. Besides the container traffic (IMEX) most of the bulk and forestry traffic is export commodities like coal and logs. It is estimated that rail carries 26% of all NZ's exports by weight.[47]

5.3.4 Key traffic statistics – passengers

KiwiRail has a limited number of passenger trains, focused on the tourist market. The Capital Connection is an exception, as it is a commuter service.

Table 5.2 KiwiRail "Great Journeys" passenger trains 2018/19

	Northern Explorer	***Coastal Pacific***	***Tranz Alpine***	**Total long distance**	***Capital Connection***
Route	AKL-WLG	CHC-Picton	CHC-Greymouth		Palm N-WLG
Frequency	Alternate days each direction	Daily return (summer)	Daily return		Weekday return
Patronage (000)	46	34	151	231	111
Tare tonne km (millions)	43.41	16.03	35.25	94.70	14.22

Source: WP C11.5, Table 7

With Covid-19 service frequencies have been altered, and currently (May 2022) the Northern Explorer and Coastal Pacific are not operating but are planned to restart in late September.

5.4 Valuation of the rail system assets

5.4.1 Valuation basis and summary:

The book values for the main asset categories are given in the KiwiRail *Annual Reports*. However, the values shown are the result following extensive impairment, particularly of infrastructure, rolling stock and work in progress. Consequently, they do not represent the total expenditure on assets since they were vested in KiwiRail in 2012. Nor do they represent economic values. For these reasons a steady state valuation has been used for infrastructure and rolling stock, Working Paper C11.3 gives details. These asset valuations are also different conceptually to the commercial valuation in KiwiRail's 2023-2025 Statement of Corporate Intent, which recorded a positive DCF equity value of $94 million.

5.4.2 Infrastructure

Infrastructure steady state is derived from the "renewals" estimate for 2030/31 in the RNIP supporting documents, deflated at 2% back to this study's base year, 2018/19. It includes an allowance for capital overheads. 2030/31 is the tenth year in a series that shows an early peak and later decline in expenditure for infrastructure assets. The tenth year might be expected to be nearing steady state.

5.4.3 Rolling stock

Rolling stock was valued on two bases:

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[47] KiwiRail *Integrated Annual Report* 2019, p 7

- Replacement costs less depreciation. Much of the fleet in the study year was beyond its depreciation life and thus has nil value on this basis. There was only minor scope for optimisation as the vehicles that could be optimised were beyond their depreciation life, apart from some container wagons, where optimisation would reduce the overall wagon fleet value by 4%. This valuation understates the assets required to run the railway, owing to the large number of old vehicles then in the fleet.
- For the purposes of estimating a steady state there was an alternative valuation on the basis of replacement costs for the whole fleet, less optimisation gains, and the assets assumed to be at half life. This is the preferred method for this study.

5.4.4 Other assets

KiwiRail assumes the book values of plant and equipment are a reasonable indication of their value, and do not attempt an ODRC valuation. This is also assumed here, with the very minor impairments not removed. The book value of plant and equipment is $126m; assuming 90% is freight related, the value is $114M. Land valuation is discussed above.

5.4.5 Asset valuation and return

The assumed rate of return for the whole DTCC study is 4% real. Applying this yields the following return.:

Table 5.3: Summary of asset values and return for rail freight and long-distance passenger

Asset type	Valuation $M	Return @ 4% pa $M
Land	1,508	60.3
Infrastructure	5,010	200.4
Rolling stock **- locomotives**	507	23.9
- wagons/containers	362	14.5
- passenger cars	90	3.6
Other assets	201	8.0
Total	7,768	310.7

Source: WP C11.3, Tables 6 and 7.

The values for passenger cars are fully attributable to the passenger operation, and wagon/ containers to freight. Land, infrastructure,[48] locomotives, and other assets are shared between long distance passenger and freight, but passenger only has a very small share (1% on gross tonne km).

5.5 Rail safety

5.5.1 Performance

The incidence of rail casualties is very sparse, with few in total each year, and fewer still, sometimes none, in finer categorisations. As well, the numbers vary considerably from year to year. For these

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[48] The infrastructure figure is derived from the valuation in AJHR B11 (above n 14, p 95). That gives a total of $6,407M, made up of “rail infrastructure” ($6,264M) and buildings and work in progress ($143M). The total is allocated to metro and freight. The allocation in this paper differs from that in the B11 paper.

reasons the approach was to take an average of a time series for the ten calendar years 2010-2019. From the basic data supplied by the regulator Waka Kotahi, there were 14.8 deaths a year on average over 10 years, and 6.8 serious injuries. This data was expanded to include minor injuries, and type of train, using KiwiRail information. From the expanded data, most deaths and serious injuries were associated with freight trains, followed by urban passenger trains. Urban areas had a much greater density of trains than rural areas, but there was also a higher level of protection in urban areas.

Table 5.4 Ten calendar year average casualty data

	Level Crossings	Unauthorised Access	Other	Total
Deaths	4.9	9.7	0.2	14.8
Serious Injuries	3.8	1.2	1.8	6.8
Minor injuries	5.3	1.1	0.2	6.6

Source: principally Waka Kotahi. See WP C11.6, Table 2

These numbers included 1.2 serious injuries a year to employees (no deaths), and no deaths or serious injuries to passengers from actual collisions, although there were a small number of platform and boarding/alighting deaths and injuries.

Nearly all the non-level crossing deaths were from unauthorised use of the corridor, 65% of all deaths including level crossings, but a much lower proportion of serious injuries (16%). Some 60% of the deaths were suicides.

In the accidents involving passenger trains, in almost all cases it is not the passenger who suffers the cost but people in cars or non-employees on the track. So, calculations of cost per passenger km are misleading. For a person comparing modes with respect to risk of travel, it is not useful to compare the rail costs with other modes. Train passengers bear very little of the rail costs, but car users bear a large share of the costs from collisions either with a train or other object.

5.5.2 Attribution of crossing accidents and suicides

Level Crossings

Level crossings can be seen simply as intersections, but between a road and a railway. An analogy would be an intersection between two roads of different levels in the hierarchy, say a secondary road and a major road. As such they are treated in a similar way to road intersections. Nearly all (95%) public level crossings in New Zealand have at least a give way sign or a stop sign. They have the same legal force at a level crossing as at a road intersection.

Irrespective of the type of sign (or no sign) the road driver must give way to a rail vehicle which is within 800m of a crossing and must not drive across a crossing when there is a risk of collision with a rail vehicle.[49]The consistent impact of the legislation and road user rules is to put the liability on the motorist to give way to the train. If he or she fails to do so, and a collision occurs, prima facie the road driver is at fault. For that reason, level crossing accidents are road accidents and not rail accidents. Even though they may involve a rail vehicle, that vehicle is not the cause of the accident.

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[49] Land Transport (Road User) Rule 2004, Rule 9.1

On this basis 100% of level crossing casualties are thus attributed to road. This makes little difference to the road costs, but rail freight costs per ntkm would rise substantially if a share was attributed to rail (although still well under road's safety costs).

Unauthorised use of the rail corridor

"Unauthorised use" is a substantial contributor to the statistics. 9.7 of the 9.9 non-level crossing fatalities in Table 5.4 are due to people with no right to be there. There is no right of access to a railway without permission. In fact, over 65% of all fatalities on the railway relate to these people.

A number of those on the corridor without authority will be people seeking an informal shortcut or have lost their way. But a large number in KiwiRail's incident data are clearly deliberate acts, such as lying down on the tracks, jumping in front of a train, or jumping off a bridge into a train's path. Official statistics show 61 deaths by suicide with trains in the 10 years to 2017.[50] TrackSAFE NZ estimates that about 60% of all 'unauthorised use' fatalities since 2012 have been intentional.[51]

Waka Kotahi does not adjust its rail figures for suicides. They are however excluded from road accident data.[52]

Railways may offer an opportunity to commit suicide, but if they did not exist, other means would be found. In fact, they are a relatively uncommon means for suicide, being involved in only 1% of all suicides.[53] Railways per se are not the cause of suicides. For the purposes of this study, the estimated suicide fatalities are not included as a rail cost, just as they are not for road.

5.5.3 Economic costs of safety

The casualties were quantified in monetary terms by using the Ministry of Transport's Value of Statistical Life ("VoSL") and other social costs. VoSL includes loss of life and life quality, and other social costs cover loss of output from temporary incapacitation, and medical, legal, and vehicle damage costs. In addition, the Ministry has calculated the vehicle damage costs for non-injury crashes.

The total deaths were valued at $67.5 million p.a, and serious injuries $3.1 million p.a. An estimate was made of minor injuries using KiwiRail information, and they were valued at $0.2 million. The total costs of death and serious injury was thus $70.9 million per annum. Of this, $44.9 million was from unauthorised access, $24.3 million from level crossings, and $1.8 million from other types of incidents.

The table below includes these costs and as well estimates of freight delay, mainline derailments, level crossing protection and damage, and TAIC and other administration.

5.5.4 Comparison of road and rail freight safety costs

Road and rail freight costs can be compared on a per ntkm basis. In the road crash WP (D1) the costs are assessed on the basis of an 8.37t load. This results in a cost per net tonne km of 1.5 cents, However, on the reasonable assumption that crash costs are related to VKT, the load assumption changes the ntkm and the resultant safety costs per ntkm. WP C5 (Table 4.3) estimates an average load of 17.3t as a more

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[50] Cf 48 for road. Source: Ministry of Health Mortality Data Collection.

[51] TrackSAFE NZ, Megan Drayton, pers comm.

[52] See "Exclusions", Ministry of Transport "Glossary" https://www.transport.govt.nz/statistics-and-insights/Glossary-and-references/

[53] 6 out of 584 total suicides in 2017 (provisional; cf road 10). Analysis of all methods of suicide, Chris Lewis, Ministry of Health, pers comm.

comparable figure with rail transport (road largely competes with rail with heavy trucks on State Highways). On the basis of the social costs alone, road freight casualties cost 0.73 cents per ntkm, and 0.2 cents on rail. If road policing and external safety administration costs for rail are added, the road figure is unaltered and the rail figure rises to 0.3cents.[54]

Table 5.5 Summary of rail safety costs ($M)

	Rail	Road	Not transport	Total
Casualty and incident costs	26.1	24.3	26.6	77.0
Other costs	12.1	2.7	0.0	14.8
Total	38.2	27.0	26.6	91.8

Source: WP 11.6, Table 4.1. “Road” casualty costs are the level crossing costs, “Not transport” are the suicide costs.

5.6 Long run variable costs

5.6.1 Operating costs

A cost is variable if it moves directly in response to changes in volume, that is if an additional tonne-kilometre is carried the costs increase. Variable costs are a close proxy for marginal costs. In a railway environment such a change is often very small, and most costs would be effectively fixed over a quite large change in output. However, many of these changes cause small incremental changes in costs that eventually get reflected in actual costs on the ground, for example when a significant extra traffic makes trains heavier and so consume more fuel. It is more appropriate to regard all such costs as variable, as they eventually do result in increased costs.

Fixed operating costs are those that do not vary even at the level of the train or line. Before network costs, these are ferry costs for rail freight, buildings and corporate costs.

Network operating costs consist of inspection and maintenance costs. Inspection costs do not vary with traffic levels, except on a very long-time frame, and are regarded as fixed. Part of the maintenance cost is not related to wear but to environmental degradation like rust and other decay. In an analysis prepared in the context of Track User Charges, the variable costs were assessed at 41% of infrastructure maintenance and operating costs. The remaining operating and maintenance costs do not vary (or only marginally) with train movement, like bridge maintenance, and formation work. Overall network fixed operating costs were assessed at 59% of the total.

That analysis did not include the corporate overheads, nor buildings. Nor did it include the variable aspects of train control. Adjusting for these we can estimate the overall level of network variable costs at 25% and fixed 75%. This makes the variable component for freight [redacted] and the fixed [redacted]

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[54] Further detail is in Appendix G to WP C3.6

Adding these to the non-network costs we get a total variable cost of [redacted] 66% and a fixed cost of [redacted] 34%.[55]

5.6.2 Variability of capital costs

In principle, all wagon and locomotive and similar asset investment is variable with usage in the long run. However, once purchased the capital costs are not variable for many years and can be regarded as fixed costs. At the margin increased usage of such assets has no cost, until they wear out and are replaced, or the demand exceeds the capacity of the fleet and new capacity is needed.

Most infrastructure assets are also fixed costs. Once purchased their usage does not diminish their value. Again, those assets have zero marginal costs with usage. These include assets with very long lives like bridges, tunnels, and formation.

Track itself has a number of elements that do wear with usage, and which can be regarded as variable costs, such as rails and ballast. Not all their deterioration is due to use, as some of it is related to environmental factors like rusting.

The overall variability of track is assessed at 31% (from Track User Charges analysis). Track is 48% of the RNIP figures, so 31% amounts to 15% of the total RNIP figures being variable: and 11-12% of the overall annual capital costs excluding ships ($316M), and of freight only ($307M).

While the business overall makes deficit of [redacted].
The government now funds networks, so the overall position above does not indicate the position of the above rail business. Before Track User Charges, but including capital charges, the broadly estimated net position for the above rail business is [redacted] [56]

5.7 Financial and economic performance summary

The following table summarises the fixed and variable operating and capital costs of the railway.

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[55] Redactions by KiwiRail

[56] Redactions by KiwiRail

Table 5.6 Total fixed and variable costs

$M	Total Freight	Networks	Train operations	Long distance passenger*
Operating costs	Data withheld by KiwiRail			
Fixed				
Variable				
Total Operating				
Capital costs				
Fixed				
Variable				
Land				
Return Fixed				
Return Variable				
Return total				
Total Capital				
Total Costs				
Fixed				
Variable				
Total				
Revenue	402.7		402.7	30.9
Margin on total costs	Data withheld by KiwiRail			
Margin on variable costs				
Safety costs external to KR	14.5		14.5	0.9
Environmental	90.4	0.4	90.0	0.4

- Source: WP C11.3

Chapter 6: Urban Public Transport

6.1 Overview

This chapter sets out the DTCC analyses relating to NZ Urban Public Transport (UPT) passenger services. The three principal UPT modes in NZ are bus (all regions), urban rail (AKL and WLG) and urban ferry (principally AKL, but also plays a small role in several other regions).

The work has focused on three main topic areas, each of which are covered in this Summary:

- ***Section 6.2***: ***Overview of the national picture***. These analyses focus on the 2018/19 UPT supply, demand and cost statistics and performance measures, on a national aggregate basis and a regional basis, and also broken down between the three main UPT modes. Additional analyses, covering the 6 years 2018/19 – 2023/24, were requested subsequent to completion of the original version of this working paper: these are summarised in Appendix D.
- ***Section 6.3***: ***Case study appraisal of Wellington urban rail services***. This analyses the total costs, average costs and user charges (fare revenues) for Wellington's 2018/19 urban rail system, disaggregated by time period and rail line. Additional analyses address the marginal (financial) costs associated with changes in service levels and with exogenous changes in demand.
- ***Section 6.4***: ***Case study appraisal of Wellington bus services***. This analyses WLG bus service costs, patronage and fare revenues to assess financial performance (total costs, average costs, fare revenues and subsidies) in aggregate and by peak/off-peak periods. It also assesses the marginal (financial) costs associated with changes in levels of service by time period; and the marginal 'economic' costs (including externalities) resulting from exogenous demand changes and consequent adjustments to service levels. All these analyses for the bus system have been undertaken at a region-wide level: analyses by individual corridor or route have not been carried out.

Consideration of the school bus services provided by the Ministry of Education (mainly in rural areas) was outside the scope of the DTCC study. However, some aggregate statistics for these services and some broad comparisons with the urban bus services covered in this paper are provided (refer Appendix C).

We also note that the paper focuses on the direct financial and economic effects of and within the urban public transport sector. External impacts associated with this sector and changes to the sector, such as congestion and environmental impacts, are the subject of other DTCC working papers.

6.2 National Picture

6.2.1 Setting the scene

The local (predominantly urban) public transport services in New Zealand are provided largely by buses, which operate within and to/from 13 urban centres. Urban rail services also serve the two largest centres (Auckland, Wellington); while local ferry services operate mainly in Auckland but also on single routes in several other centres.

These public transport services are primarily the responsibility of the relevant regional councils. These councils are responsible for determining service levels, hours of operation and fare levels, as specified in regional public transport planning and policy documents. All the services are contracted out to private operators, with the regional councils being responsible for operator procurement through periodic competitive tendering and also for ongoing contract management. Contract prices for bus and ferry services were previously determined through the tendering process on a net cost basis in almost all cases (i.e., the operator tendered a net price, representing the difference between their estimated costs and their expected fare revenues, and they retained all passenger revenues collected). With the introduction of the NZ Public Transport Operating Model (PTOM) in recent years, the previous net cost contracting model has been replaced by a gross cost model, with operators bidding on the basis of expected gross costs and with all passenger revenues being returned to the regional council.

Local (city/district) councils also have a modest role in the provision of local public transport services, principally through the provision of on-street infrastructure, such as bus priority lanes, bus stations/interchanges, street signage, bus stop facilities, etc.

Apart from the local council roles (and associated funding), the costs of local public transport services are funded between three main parties, i.e., users of the services (through fares), regional councils and central government (through WK). The total gross costs of some $1300 million pa (2018/19) were funded approximately 28% through fares, 31% by regional councils (which recover these costs mainly through regional rates) and 42% by central government (recovered mainly through general taxation).[57]

6.2.2 Local public transport service statistics and performance

Table S2.1 provides a summary of 2018/19 NZ local PT statistics and performance ratios, at a national aggregate level and broken down by the three main PT modes. Brief comments are as follows:

Patronage and fare revenue:

- On a national level, bus services accounted for some 74% of all PT passenger boardings, 56% of passenger kilometres and 59% of fare revenues. Train services accounted for 21% of boardings, 38% of passenger kilometres and 29% of fare revenues. Ferry services accounted for the residual proportions (between 5% and 11% on each measure).
- Bus trips averaged some 7 km, much shorter than train trips (17 km) and ferry trips (12 km)[58].
- Bus fares in all the main urban regions (together with train fares (in both Auckland and Wellington) are based on concentric zonal fare systems but within a broad 'flag-fall plus distance' fare structure. Consequently, given that urban train travel generally involves longer distances than the urban bus travel, all the average fare per boarding for buses is lower than that for trains, but the average fare per passenger km is generally higher for buses.

Operations, operating costs and cost recovery:

- Of the total gross costs ($1306 million in 2018/19), the bus services accounted for some 66%, the train services for 28% and the ferries for 6%.
- The farebox cost recovery for the three modes was 25% for bus, 29% for train and 54% for ferry. After allowing for the fare revenues, the split of net subsidies across the three modes all was 69% for bus, 27% for train and 4% for ferries. So, the relative performance of bus and train in terms of recovery of costs from fares was broadly similar. Unsurprisingly, the net subsidy per passenger boarding was higher for train (average $7.22) than for bus (average $5.18), whereas the subsidy per passenger kilometre was substantially higher for bus ($0.73) than for train ($0.43). [59]

Not shown in table S2.1, but of considerable relevance in understanding the NZ public transport market, are the differences between the larger (metropolitan) centres and the smaller urban centres and their

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[57] No attempt is made in this paper to cover PT funding arrangements in more detail.

[58] Note that these figures are the average distances per boarding, while a complete passenger trip may involve more than a single boarding.

[59] It should be noted here that, in general, the train services operate in the higher demand corridors, whereas most of the bus services operate in corridors of much lower demand. Further analysis would be required to assess the relative financial performance of the two modes on more comparable corridors (e.g., comparing the AKL Northern Busway services with the train services in the AKL rail corridors).

catchment areas. The three largest regions (in PT terms) together account for 91.5% of all local PT trips made in NZ: Auckland accounts for 59.3%, Wellington for 23.9% and Christchurch for 8.2%; while all other centres combined account for the remaining 8.5%. An alternative perspective on this is the relative PT trip rates per person in the different regions: the average local PT trip rate for NZ urban centres (2018/19) was 42.4 trips per year; but this figure was made up of an average of 59.2 trips across the three dominant regions, 13.8 trips for the four 'medium' regions in PT terms (Waikato, Otago, Bay of Plenty, Manawatu -Wanganui) and only 4.7 trips on average for the remaining six regions.

In general, we find that the cost recovery performance of PT services is relatively constant over the different regions: for most regions (including those with relatively low levels of PT usage), the cost recovery ratios (i.e., fare revenue: total operating costs) are in the range 25% - 30%, with Wellington being the most notable outlier, with a ratio of 38%. Taken together with the relative trip rates by region, this means that the pattern of subsidy is very skewed towards the major regions with high PT use, but is approximately proportional to the extent of usage: for example, the three largest regions account for 91.5% of total boardings and 90.8% of total subsidies (ie including both national and regional funding sources), whereas the six regions with the lowest PT trip rates together account for only 1.4% of total boardings and 1.3% of the total subsidy.

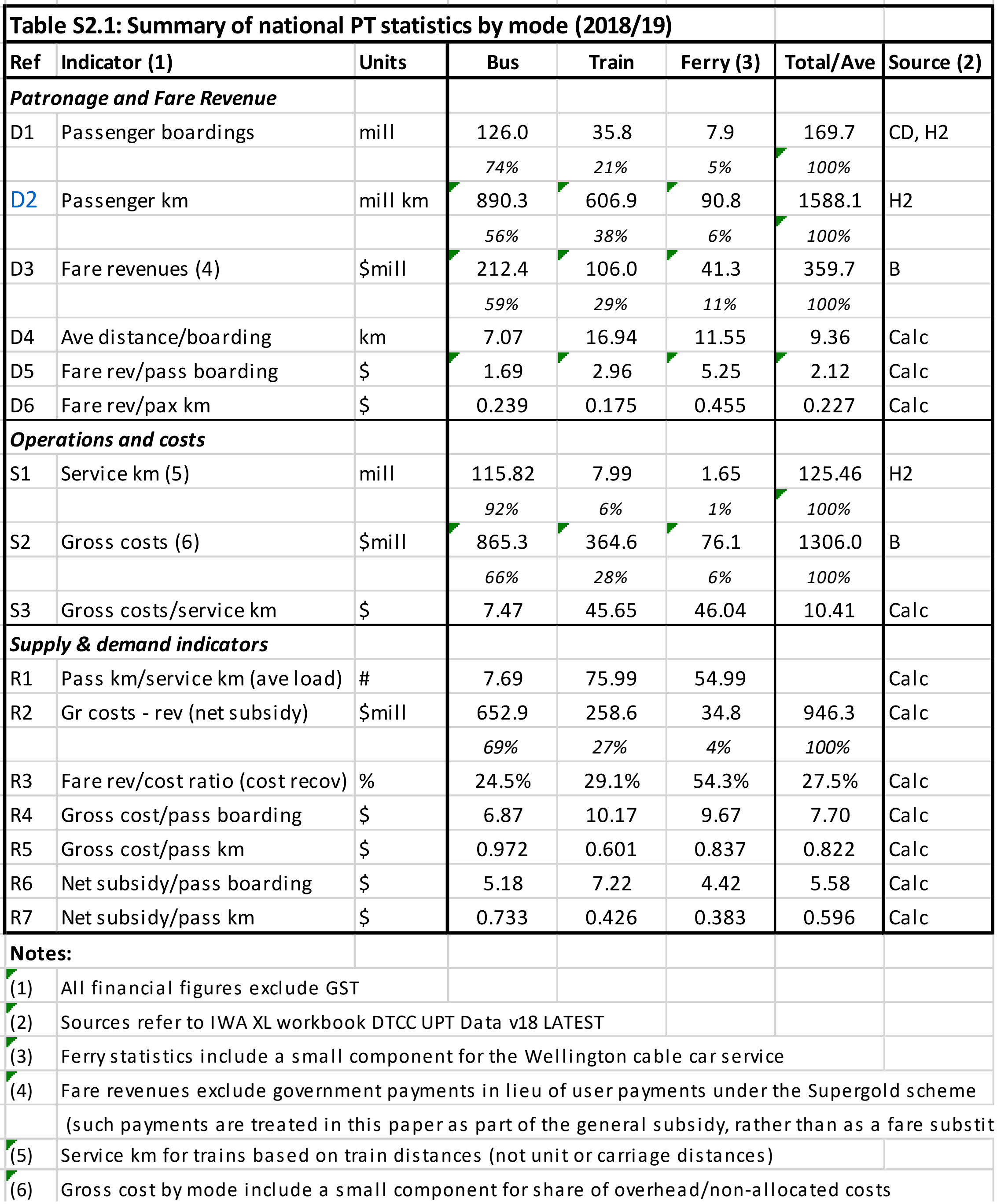

Table S2.1: Summary of national PT statistics by mode (2018/19)

Ref	Indicator (1)	Units	Bus	Train	Ferry (3)	Total/Ave	Source (2)
Patronage and Fare Revenue							
D1	Passenger boardings	mill	126.0	35.8	7.9	169.7	CD, H2
			74%	*21%*	*5%*	*100%*	
D2	Passenger km	mill km	890.3	606.9	90.8	1588.1	H2
			56%	*38%*	*6%*	*100%*	
D3	Fare revenues (4)	$mill	212.4	106.0	41.3	359.7	B
			59%	*29%*	*11%*	*100%*	
D4	Ave distance/boarding	km	7.07	16.94	11.55	9.36	Calc
D5	Fare rev/pass boarding	$	1.69	2.96	5.25	2.12	Calc
D6	Fare rev/pax km	$	0.239	0.175	0.455	0.227	Calc
Operations and costs							
S1	Service km (5)	mill	115.82	7.99	1.65	125.46	H2
			92%	*6%*	*1%*	*100%*	
S2	Gross costs (6)	$mill	865.3	364.6	76.1	1306.0	B
			66%	*28%*	*6%*	*100%*	
S3	Gross costs/service km	$	7.47	45.65	46.04	10.41	Calc
Supply & demand indicators							
R1	Pass km/service km (ave load)	#	7.69	75.99	54.99		Calc
R2	Gr costs - rev (net subsidy)	$mill	652.9	258.6	34.8	946.3	Calc
			69%	*27%*	*4%*	*100%*	
R3	Fare rev/cost ratio (cost recov)	%	24.5%	29.1%	54.3%	27.5%	Calc
R4	Gross cost/pass boarding	$	6.87	10.17	9.67	7.70	Calc
R5	Gross cost/pass km	$	0.972	0.601	0.837	0.822	Calc
R6	Net subsidy/pass boarding	$	5.18	7.22	4.42	5.58	Calc
R7	Net subsidy/pass km	$	0.733	0.426	0.383	0.596	Calc

Notes:

(1) All financial figures exclude GST
(2) Sources refer to IWA XL workbook DTCC UPT Data v18 LATEST
(3) Ferry statistics include a small component for the Wellington cable car service
(4) Fare revenues exclude government payments in lieu of user payments under the Supergold scheme
(such payments are treated in this paper as part of the general subsidy, rather than as a fare substit
(5) Service km for trains based on train distances (not unit or carriage distances)
(6) Gross cost by mode include a small component for share of overhead/non-allocated costs

6.3 Urban Rail Services—Wellington Case Study

6.3.1 Wellington's urban rail system

Key characteristics of the Wellington urban rail system include the following:

- Total network length of 154 route kilometres (most routes are double-tracked) and 53 stations.
- The network comprises three main lines, radiating from Wellington Railway Station: (i) Kapiti line (to/from Waikanae); (ii) Hutt Valley/Wairarapa line (to/from Upper Hutt and Masterton, with a branch line to/from Melling); and (iii) Johnsonville line (to/from Johnsonville).[60]

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[60] A 'semi-urban' rail passenger service (the 'Capital Connection') also operates between Wellington and Palmerston North. This service is not covered in this paper, as it is not generally regarded as an urban service: it is managed and funded separately (through Kiwirail rather than the Greater Wellington Regional Council).

- The majority of the route length is electrified (overhead wires), with the great majority of services being operated by 83 2-car Matangi EMUs, which have been introduced in two tranches since 2007. The remaining services (to/from the Wairarapa area) continue to be operated by a small diesel-hauled carriage fleet (but future options for these services are currently under review).
- Most of the rail system assets (including the EMUs) are owned and controlled by GW, while most operational and maintenance functions are contracted out, through two main contracts: (i) contract with Kiwirail, for long-term access rights to the rail network in the region together with the provision of network maintenance and train control functions; and (ii) contract with Transdev, for the operation of passenger services and maintenance of the rolling-stock.
- Total value of the rail-related assets owned by GW is $476.5 million.

6.3.2 Total rail operating costs

Total operating costs for the Wellington rail system (2018/19) were some $148 million, disaggregated as shown in table 6.3.1.[61]

Table 6.3.1: Summary of Wellington Rail Operating Costs and Capital Charges 2018/19

Cost item	**Cost - $mill**	**Notes**
Operating costs:		
Rail operations	60.67	Most of these costs are payments to Transdev for the operating contract.
Network operations and access	34.85	Most of these costs are payments to KiwiRail for network operations, maintenance and renewals (Including network traction electricity)
Occupancy costs	5.17	These costs relate mainly to station expenditures, security, lease charges and rates
Metlink & management services	12.08	Comprises GW common services (information, ticketing etc) and management overheads
Total operating costs	**112.77**	
Capital charges:		
Depreciation - rolling stock	13.40	Depreciation charges as used for accounting purposes
Depreciation – stations etc	3.04	
Capital charge - rolling stock	14.61	Economic capital charges calculated as 4% of the depreciated asset values (included for study purposes)
Capital charge – stations etc	4.23	
Total capital charges	**35.28**	
Grand total costs	**148.05**	

6.3.3 Rail system performance statistics and allocated cost analyses

Table 6.3.2 provides some key performance statistics (2018/19) for the Wellington rail system. At an aggregate level, some 14.3 million passenger journeys (boardings) were made with total fare revenue of $53.1 million. This resulted in overall cost recovery of 36% and an average subsidy per passenger journey of $6.63.

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[61] The cost figures given in table S3.1 are identical with those given in GW's rail system accounts, with the exception that we have added in a capital charge on assets (rollingstock, stations etc) of some $19 million, which represents 4% of their total depreciated asset values ($476.5 million): inclusion of this cost component is consistent with wider practice across all capital assets in the DTCC study.

Table 6.3.2: Summary of Wellington Rail Performance Statistics - Peak vs Off-peak

Item	**Units**	**Peak** (1)	**Off-peak**	**Total**
Passenger boardings	million	9.54	4.78	14.32
Passenger kilometres	million	231.5	108.0	339.5
Fare revenues (2)	$million	37.5	15.6	53.1
Fare revenue/boarding	$	3.93	3.26	3.71
Fare revenue/pass km	$	0.162	0.144	0.156
Gross costs	$million	88.0	60.0	148.1
Cost recovery	%	43%	26%	36%
Subsidy/passenger	$	5.30	9.28	6.63
Subsidy/passenger km	$	0.22	0.41	0.28

Notes*: (1) Peak period covers all weekday trips departing their origin station before 0900 and between 1500 and 1830; all other trips are categorised as off-peak.*

(2) Fare revenues exclude Supergold Card reimbursement payments from Government (i.e., these are treated as part of the general subsidy).

The table also provides a breakdown of statistics between peak and off-peak periods. It is seen that the demand profile is highly peaked, with approximately twice as many boardings in the peak periods as in the off-peak periods. Given this demand pattern, the 'supply' profile is also highly peaked, primarily through the provision of longer trains (up to 4 coupled units, i.e., 8 cars) in peak periods compared with generally single units outside these periods. Our 'neutral' allocation of costs, as shown in the table, indicates that total peak period costs ($88.0 million) are some 50% greater than off-peak costs ($60 million).[62] Based on this cost allocation, it is seen that the cost recovery performance in the peak periods (43%) is considerably higher than in the off-peak periods (26%); and the subsidy per passenger (and per passenger km) in the peak periods is only just over half that in the off-peak periods.

Further analyses of financial performance by line and time period, focusing on the two main lines (Kapiti Coast and Hutt Valley) which account for some 80% of system patronage, indicates that the cost recovery proportions tend to increase with trip distance while the $ subsidy per boarding remains fairly constant with distance: the subsidy levels for travel to/from the outer ends of these two lines (ie Waikanae and Upper Hutt) are around $10 per boarding, somewhat lower in the peak periods, higher in the off-peak periods.

6.3.4 Marginal cost analyses

Marginal costs were examined for both peak and off-peak periods, on two bases, ie: (i) a supply-based perspective, assessing the costs at the margin of increasing service levels, in peak and/or off-peak periods; and (ii) a demand-based perspective, assessing the service level and related cost impacts of exogenous increases in passenger demand. The findings may be summarised as follows:

- ***Off-peak periods.*** There is more than adequate capacity on the present off-peak services, so the marginal costs of accommodating additional passengers would be minimal. If additional services were required for any reason (e.g., to improve service frequencies on 'policy' grounds), the incremental costs for these would be relatively modest, less than half the costs (per unit hour) of an equivalent service increment in peak periods.

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[62] This allocation of costs has been undertaken primarily on the basis of train or unit hours, train or unit kilometres and units in service. The main component of joint costs relates to the units in service: all the costs for the peak-only units have been allocated directly to the peak period; while the costs for those units used in both peak and off-peak have been allocated in proportion to their unit hours operated in each period. All

- ***Peak periods***. The current services have been specified so that they are effectively full to capacity (based on current NZ loading standards) in the peak period/peak direction at their maximum load point. Any significant increase in peak period demand would therefore require a proportionate increase in peak capacity -- which would translate in practice into a similar proportionate increase in total units required in the fleet and number of trains operated in the peak period. To run one additional (6-car) train in both peak periods would involve an additional cost (including annualised capital charges, principally for additional EMUs) of around $4.3 million pa, with incremental passenger revenue of around $1.4 million pa (on the basis that this train would have similar loadings to the existing services). Per incremental passenger, the gross costs would be around $10.50 per trip and the fare revenues around $3.30.

6.4 Urban Bus Services—Wellington Case Study

6.4.1 NZ Urban Bus Cost Model

Rather than base our case study analyses directly on the 2018/19 contracted costs for operating bus services in the Wellington region, we developed a set of unit cost rates which are more representative of the costs applying (in early/mid 2019) to competitively tendered contracts in the main NZ regions. These rates were established through an open tendering process (in most cases in 2018) in each region: this process resulted in relatively similar cost rates across tendered contracts in all the main regions. These rates have been used as the basis for all our analyses for urban bus services in the following summary and in Chapter 4.

However, we note that in recent years (under the PTOM regulatory/contracting model) substantial proportions of the bus service contracts in Wellington (and also in Auckland) were subject to a negotiation process with incumbent operators rather than competitive tendering: in general, these negotiated contracts in both these regions resulted in significantly higher cost rates than the tendered contracts in these and the other main regions[63]. These higher rates have been used in chapter 2, which is based directly on the annual financial statistics for each region.

The bus cost model developed for the Wellington bus case study (details in section 4.2) is as follows:

Total cost = $49.22 * service hours + $1.66 * service kms + $52,600 pa * peak buses.

Note that: (i) the model relates to 'standard'-size (c 40 seat) diesel buses; (ii) the 'peak bus' term includes an annualised (depreciation and interest) charge to reflect bus capital costs; and (iii) the model is expressed in terms of service hours and kilometres based on timetable statistics only (typical allowances for dead running etc are incorporated in the unit rates).

Applying this model to a typical urban bus running 50,000 service kms pa at an average speed of 22 km/hr, the total costs would be approximately $250,000 pa: this could also be expressed as an average cost of approximately $5.00 per service km or $110 per service hour.

We note that this bus cost model is essentially a financial (rather than economic) model, although there is little difference in this case: the model includes road user charges, licence fees etc on a comparable

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[63] This cost differential for negotiated contracts was particularly high for the Wellington contracts. For more details, refer: Wallis IP. Value for money in procurement of urban bus services -- competitive tendering versus negotiated contracts: recent New Zealand experience. Research in Transportation Economics 83, 2020.

basis as for trucks of similar weight and axle configuration, so in effect the buses are paying their 'fair share' of the total costs of using the road system.

6.4.2 Financial assessment -- allocated costs and charges (Wellington)

Based principally on information provided by GW for their 2018/19 bus operations, a database was established covering the following statistics (split between peak and off-peak periods)[64]:

- Service km, service hr, maximum bus requirements
- Passenger boardings, passenger kilometres
- Fare revenues, Supergold revenues.[65]

This database was applied along with our costing model (above) to undertake a financial analysis of the 2018/19 bus services, both in total and split between peak and off-peak periods. With this model formulation, the great majority of costs are able to be attributed uniquely to one or other of the two time periods: this applies to all the costs relating to service km and service hr plus that proportion of the bus-related costs corresponding to the buses in operation in the peak periods only. The remaining costs, relating to buses required for both peak and off-peak periods, accounted for some 12% of total costs[66].

Table 6.4.2 summarises the resulting performance statistics, split between peak and off-peak periods. On most performance measures, the peak statistics accounted for around 55% of the total, the off-peak for the remaining 45%. The cost recovery (fare revenues: operating costs) ratio is significantly higher in the peak periods (60% as against 52%), and the subsidy/boarding and subsidy/passenger km are significantly lower (by about 10%) in the peak periods.

Table 6.4.2: Allocated Costs and Charges Summary (2018/19), Wellington bus[67]

Item	**Units**	**Total**	**Peak**	**Off-peak**
Boardings	mill	24.747	13.200	11.547
Pax km	mill	162.4	84.6	77.7
Fare revenues	$ mill	42.20	4.24	17.96
Service hours	000	608.5	300.3	308.2
Service kms	000	14741	7085	7656
Allocated costs	$ mill	74.93	40.64	34.30
Net subsidy	$ mill	32.74	16.40	16.34
Revenue: cost ratio	%	56.3	59.7	52.4
Subsidy/boarding	$	1.32	1.24	1.42
Subsidy/pax km	$	0.202	0.194	0.210

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[64] Peak period services were defined as those starting before 0900 and between 1500 and 1830 on weekdays; all other services were defined as off-peak (these definitions are consistent with those used for Supergold Card validity)

[65] 'Supergold' is the standard national scheme involving reduced fares for pensioners etc, with government essentially providing a separate subsidy to regional councils to cover the difference between full fares and these reduced fares. Throughout this paper we have treated the Supergold payments from government as an additional component of overall subsidies (rather than an additional component of passenger fare payments).

[66] For the purposes of this allocated cost analysis, these joint costs were allocated between peak and off-peak periods in proportion to the bus hours that they were estimated to operate in each of the periods. Note that this allocation is for illustrative purposes only: it should not be used for policy analysis purposes, as it does not reflect the incremental (avoidable) costs associated with changes to services in either peak or off-peak periods (refer S4.3).

[67] Most of the data in this table is based on information supplied by GW. The allocated costs and the related performance ratios are based on the IWA costing model (outlined in section 4.1). The revenue figures relate to passenger fare revenues only, i.e., excluding the government financial contribution in lieu of reduced fares for Supergold (pensioner etc) travel.

6.4.3 Financial assessment – marginal cost (supply-based and demand-based) perspectives (Wellington)

Marginal (financial) costs for the Wellington bus services were assessed from two main perspectives:

- (A). ***A supply-based perspective***: this assesses the gross cost impacts at the margin of increasing (or decreasing) bus service levels, in peak and/or off-peak periods.
- (B). ***A demand-based perspective:*** this assesses the service level impacts, the related cost and fare revenue impacts and any flow-on effects to existing users and usage resulting from exogenous changes in passenger demand (such as fuel price increases).

(A). Supply-based perspective. Applying the unit costs from our NZ Bus Cost Model (section S4.1), the gross costs of marginal increases in the levels of bus service supply were estimated for peak and off-peak situations (and, by addition, for 'all day' services) at $160/service hour for a typical peak period service (operating c1.5 service hours in each peak period) and $90/service hour for off-peak services. The difference between the two cost rates reflects principally the bus capital charges associated with incremental peak period services.

(B). Demand-based perspective. This part of the assessment examined the expected service level and financial impacts to the authority (GW) in response to changes in demand (assumed at both peak and off-peak periods) resulting from some exogenous factor (such as fuel price changes). For illustrative purposes, a 10% increase in exogenous demand was assumed (but noting that our analysis results would be linear and symmetric for a corresponding decrease in demand[68].

Key assumptions were:

- The authority response to the 10% demand increase would be an average increase of 8% in peak service frequencies and 3% in off-peak frequencies (these estimates are based on our broad assessment of current spare capacities across the network and likely responses to them).
- The increased frequencies would encourage some further increased patronage through reducing bus waiting times and improving service frequencies – a patronage increase of around 2% (peak and off-peak) is estimated, which in turn might trigger further smaller increases in service frequencies.

The results indicate incremental costs of some $5.6 million pa, an increase of some 7.5% on the current total annual (gross) costs of the region's bus services. The fare revenues from the 12% overall increase in patronage would be some $5.5 million pa, almost matching the incremental costs: therefore, the net impact on subsidy requirements would be minimal. However, notably, the peak period subsidy would **increase** by about $1.7 million pa, while the off-peak subsidy would **reduce** by $1.6 million pa.

6.4.4 Economic assessment -- marginal costs and charges (Wellington)

The financial costs to the operator associated with marginal increases in patronage (as addressed above) are an example of '***operator (financial) economies of scale'***: in this case the (gross) marginal financial costs to the operator were less than the average costs of service supply, with the net marginal costs (i.e., marginal costs - marginal revenues) being close to zero.[69]

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[68] for illustrative purposes, we have assumed that the results for a reduction in demand would be symmetric with those for an increase in demand. In practice we note that reducing services in response to patronage reductions is often considerably more difficult (in the real world) than increasing services in response to patronage increases.

[69] In the example given, the net marginal costs were close to zero, but with substantial cross-subsidy from off peak to peak periods.

This section focuses on the marginal **economic** costs associated with the marginal user, i.e., the net increase in (gross) operator costs less economic benefits (travel time etc) to existing passengers that would result from any increase in service levels to accommodate the marginal passenger. These ***user economies of scale*** are often known in the public transport sector as the ***Mohring effect.*** The benefit values to existing passengers may be categorised as a '***positive externality'***, in the sense that they are not experienced by the marginal passenger but by other bus users benefiting from the presence of this passenger. [70]

These benefits to existing users associated with additional passengers are a simple function of: (i) initial headway, (ii) service frequency 'elasticity' in response to patronage changes, (iii) waiting time: headway factor, and (iv) value of travel time savings. In the case of the Wellington bus services, our estimates are that these benefit values to existing users (in aggregate) resulting from incremental passengers are typically around $0.90 - $1.40 per incremental passenger in peak periods, $0.20 - $0.40 in off-peak periods.[71]

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[70] The analogy on the road system is the 'negative externality' associated with congestion, where the presence of the marginal road user results in congestion disbenefits to other road users.

[71] The higher values for peak than off peak periods primarily reflect the difference between the two periods in initial headways and in service frequency elasticity estimates.

Chapter 7: Long Distance Coaches

7.1 Scope of chapter

This chapter covers the long-distance scheduled coach services in New Zealand. These services operate on a fully commercial basis: their operational, market and financial statistics are not generally publicly available.

In recent years, the scheduled coach market has been dominated by the Entrada Group, which trades under the names InterCity, Great Sights and Skip. Entrada is jointly owned by three bus companies – Ritchies Transport, Tranzit Coachlines and SBL (Nelson). The coach services are operated by these three companies under the oversight of Entrada.

While InterCity has faced competition on individual routes and/or in specific regions in the past, it currently has no significant competitors for the provision of scheduled coach services: the last competitor attempting to provide a comprehensive service, ManaBus, withdrew from the market in mid-2018; and, given the contraction in travel activity resulting from the Covid pandemic, it seems highly unlikely that any serious competition will emerge in the near-term future.

The chapter focuses on the operational and financial statistics of the Entrada services in 2018/19, based primarily on information provided by Entrada for the purposes of this study (and subject to confidentiality constraints). Entrada provided detailed information on its operational data by route and on its patronage and revenue data also by route and by month. Estimates of operating costs at a route and regional level were largely developed by IWA, based on a previous cost model developed for NZ coach services which was updated to 2018/19 levels (based primarily on WK published cost inflation indices for the urban bus sector).

Additional information on external costs relevant to the long-distance coach sector is covered elsewhere in this report – principally in section 4.10 (Road accidents) and chapter 11 (Emissions and noise).

7.2 Key statistics

Key statistics for the 2018/19 InterCity aggregate business (covering services, patronage, fare revenues, costs and associated performance indicators) are set out in table 7.2.1. These were either provided by Entrada or developed as part of the more detailed DTCC analyses (undertaken generally at a route level).

Note that all the operating cost estimates in this chapter relate to ‘direct‘ operating costs only for the three participating operators. Additional management and overhead costs (incurred mainly by Entrada) have not been included, as information on these was not made available: in broad terms, we would expect that these would add 20% -30% to the ‘direct’ operating costs used in our analyses.

Table 7.2.1: Summary of statistics (total and average), InterCity, 2018/19

Item	Total pa (note)
Operational (peak) vehicles	82
Vehicle kilometres (million)	13.1
Vehicle hours (000)	234
Passengers carried (million)	1.57
Passenger kilometres (million)	371.2
Fare revenues ($ million, excl GST)	$42.96
Direct operating costs ($ million)	$31.12
	Average
Average direct operating cost/veh km	$2.37
Average direct operating cost/veh hr	$132.84
Average revenue/veh km	$3.02
Average load (pax km/veh km)	28.3
Average direct cost/pax km (cents)	8.38c
Average revenue/pax km (cents)	11.58c
Total revenue/total direct cost	138%

Note: The totals given for operational vehicles, vehicle kilometres and vehicle hours here relate to in-service operations only. Spare vehicle requirements and any out-of-service running are covered in the unit costs and overall cost values.

7.3 Services, fares, patronage and revenues

7.3.1 Services

The InterCity services comprise numerous individual routes (defined in terms of start terminus, route and end terminus), which are amalgamated by Entrada into 18 service groups for management and operational purposes. In total, the services involve 82 operational coaches, some 13.1 million vehicle kms and 234,000 vehicle hours per year to cover the timetables (table 7.1). In addition, the operatrors require some additional coaches (to cover for breakdowns, vehicle maintenance etc) and some out-of-service running (for repositioning purposes etc).

7.3.2 Fares

Key features of the group fare structure are as follows:

- The fare structure is based on a ‘standard’ fare scale for adult passengers approximating to $15.00 + 7.3c* kms (incl GST). For the average trip length (230 km), the average fare per passenger was approximately $31.50 (incl GST): the flag-fall and distance components of the fare for such a trip are approximately equal.
- The fares are somewhat higher than the average on the main tourist-oriented routes (principally in the SI), somewhat lower elsewhere.
- Fare concessions are available for children, pensioners, special groups etc, with the levels of discount varying by the time of year. There are no government-mandated concessions.

7.3.3 Patronage and revenues

- In 2018/19, 1.57 million passengers were carried (24% in the SI, 76% in the NI) over a total of 371 million passenger-km, generating $43 million revenue (average fare = 11.6c/pkm).
- The level of demand is strongly seasonal: in the SI, approximately 60% of total passenger km were travelled over the six summer months (Nov-Apr); with average patronage in January being about twice that in June. These seasonal imbalances have significant implications for the operators' usage of staff and vehicles.
- Further, patronage varies markedly by day of the week: it is highest on Fridays, around 60% higher than on Wednesdays and Saturdays, the days of the lowest patronage.
- On many routes, the proportion of passengers travelling end-to-end is quite small: for example, on the Auckland - Wellington route (one of the strongest routes in patronage terms), only about 10% of passengers travel the full distance, with most 'domestic' passengers travelling between a main centre and a smaller town or city. While the coach may be 'full' at its maximum load point, it may well have spare capacity over most of its route length.

7.4 Operating costs

7.4.1 Direct operating costs

Given the commercially sensitive nature of the information, neither Entrada nor its shareholder bus companies were willing to provide detailed information on their operating costs. IWA therefore developed our own cost model that could be applied to a range of routes, vehicle types and operating situations, by the estimation of three cost components, i.e., cost per bus km (which covers the distance-related operating costs), cost per bus hour (which covers driver wages and related costs), and costs per peak bus (which covers the annualised capital costs for the bus itself).

The procedures used to derive the 2018/19 unit costs were essentially as follows: (i) start with the STCC unit costs; (ii) apply NZ bus industry cost inflation factors (based on WK cost indices) to each unit cost component (e.g., fuel), to derive an initial estimate of 2018/19 unit cost rates; and (iii) review each component of these initial estimates against current/recent industry sources (where available to IWA) and adjust estimates where appropriate. The resulting unit costs estimated are summarised in Table 7.4.1.

These unit costs were then applied to estimate the annual costs for each route group. Bus kilometres and hours by route were estimated from the published timetables. Peak bus requirements were estimated for each route assuming that buses on routes with a running time of less than six hours will make multiple trips per day. This will not always be the case, but it results in a total fleet size that accords with our understanding of the fleet requirement. Because the shareholder companies are bus and coach operators in their own right, coaches from their wider fleets can be used elsewhere in the group to cover maintenance spares and peaks in demand.

7.4.2 Overhead costs and financial viability

The above direct operating costs do not allow for many of the overhead costs involved in providing scheduled coach services on a national basis: these would include reservations, sales and marketing activities, together with supervision, administration and other overheads. Based on a range of IWA sources (and having regard to the revenues and viability of the present InterCity operations), we estimated that these overheads were likely to account for around 20% - 30% additional to the direct operating costs. On this basis, we would expect that the overall InterCity business would be covering its full costs and earning a modest profit margin.

Table 7.4.1: unit operating costs (excluding GST)

Item	Unit	35-seater ($)	53-seater ($)
Fuel (diesel)	km	0.250	0.380
Oil	km	0.033	0.043
Bus Repairs and Maintenance	km	0.179	0.224
Tyres and Tubes	km	0.077	0.102
Road User Charge	km	0.228	0.408
Cleaning	km	0.068	0.080
TOTAL per kilometre	**km**	**0.834**	**1.238**
Wage (including ACC)	hr	34.928	34.928
Capital cost(2)	Bus-week	1,379	1,573
TOTAL DOC per km @ 70 km/hr	**km**	**1.686**	**2.140**

Notes:

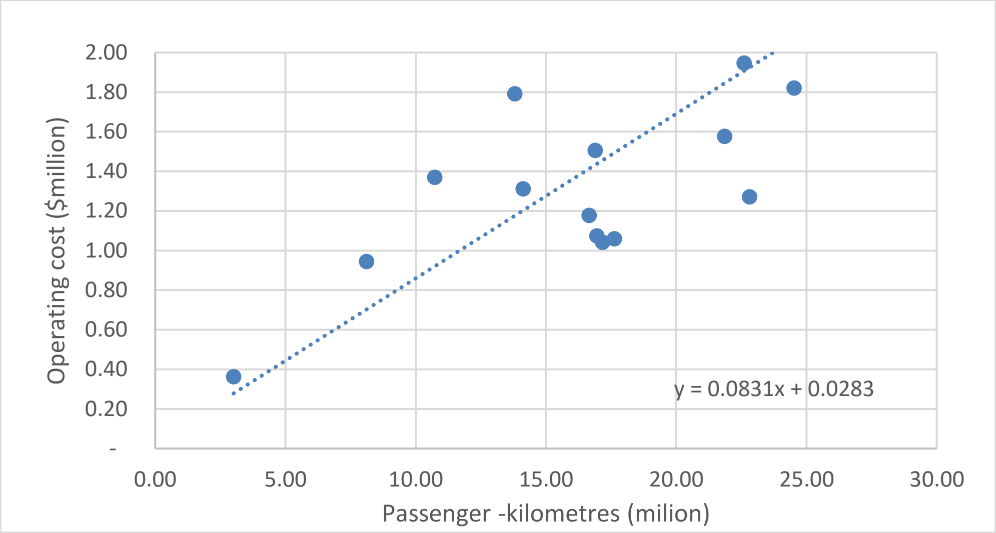
(1) Figures based on 2005 Surface Transport Costs and Charges study (inflation adjusted and reviewed against other IWA sources)
(2) Capital cost, assumes 2900 hours per annum per bus.

7.5 Average and marginal costs per passenger kilometre

It is generally assumed (nationally and internationally) that there are no economies of scale in the supply of bus and coach services. One might expect some Mohring effect whereby an increase in the number of passengers leads to higher frequencies, which in turn generates additional passengers. However, the nature of the market is such that there are times of day that are preferred by passengers – morning departures between 8am and 9.30am are generally most popular, followed by midday departures and then evening: frequency as such appears not to be highly valued. Perhaps a more valued consequence of higher passenger numbers would be the availability of more direct services – avoiding changing buses or deviating to serve towns off the direct route.

Figure 7.5.1 compares the direct cost per passenger-km between the main corridors served. While there is some scatter, there is no obvious evidence of returns to scale. The trendline is $28,300+ $0.0831 x pax-km implying a marginal cost of 8.31 cents/passenger-km, which is very close to the overall average of 8.38 cents.

Figure 7.5.1: Operating cost vs passenger-km



Chapter 8: Personal (for hire) Transport

8.1 Scope of chapter

This chapter covers:

- Taxi and ride-hail (car-based) services (with vehicle and driver) - section 8.2
- Micro-mobility (scooter-based) services - section 8.3.

It does **not** cover:

- Demand-responsive public bus services (as are currently being trialled in Timaru, Auckland and Wellington)
- 'Traditional' car/light vehicle hire services (generally vehicle only, without driver)
- Bus/coach hire services (typically vehicle and driver).

These three 'modes' are outside the scope of the study.

8.2 Taxi and ride-hail services

8.2.1 Introduction

This section presents our analysis of the costs of ride-hailing and taxi services in New Zealand:

- **Ride-hailing** refers to a service that links a rider to a driver through a technology platform, predominantly operated via a smartphone app; whereas
- **Taxi** refers to services operating under a taxi company that can be hailed off the street or dispatched by an operator.

Like many parts of the transport system, taxis and ride-hailing are undergoing rapid change. Uber's entry into the New Zealand market in 2014 has led to rapid growth in the use of ride-hailing services and subsequent regulatory changes. Several ride-hailing companies are now active in the New Zealand market, which we estimate to be—at the time of writing—split approximately 50:50 between taxis and ride-hailing services.

8.2.2 Scope and methodology

This area of work focused on establishing an operating cost model for taxi and ride-hailing operations: while the model was primarily directed at estimating total costs and average costs for a range of scenarios, it may also be readily used for assessing marginal costs.

The work has not addressed accident costs relating to taxi and ride-hail operations. Very little evidence is available specific to taxi/ride-hail services on such costs: in the instance of such specific evidence, the work done in other DTCC work-streams relating to private cars will generally give the best guide to any accident costs applying to the taxi/ride-hail sector.

Our taxi and ride-hailing operating cost (TR-OC) model builds on the private car operating cost (PC-OC) model developed elsewhere in study. The TR-OC makes several changes to reflect unique cost structures associated with delivering taxi and ride-hailing services. These changes involve both adjustments to cost components as well as the addition of several additional cost components, specifically:

- *Variable operating costs* – compared to the overall fleet makeup of private cars, we assume taxi and ride-hailing services make use of more modern vehicles that are more efficient with lower variable operating costs. This leads to different assumptions for petrol, oil, tyres, repairs and maintenance.
- *Fixed operating costs* – we allow for additional costs associated with commercial use, such as fit-out, insurance, driver licensing (Passenger Endorsements), logbooks, insurance, ACC payments, annual vehicle licensing/registration and warrant/certificate of fitness certifications.
- *Fixed ownership costs (capital charges)* – the use of more modern vehicles compared to the average car/light vehicle in the New Zealand fleet, along with a higher depreciation rate to account for commercial use (which involves increased mileage and wear and tear), results in higher capital charges on an annualised basis.
- *Labour / contracting costs* – we model the costs of payments to contractor-drivers, allowing for utilisation, dynamic (surge) pricing in situations of high demand (ride-hailing sector), and vehicle cleaning time. These components are assumed to yield an average hourly rate around the level of the minimum wage.
- *Platform and licensing charges* – representing the costs charged by ride-hailing and taxi companies to provide and/or license the platforms, including technology, marketing and profit margins.
- *Additional consumer charges* – including the costs of airport charges (for both services) and electronic transactions (for taxi users).

Estimated costs per in-service kilometre are used to estimate the cost per trip and are factored by an occupancy rate to arrive at a passenger-km rate.

In terms of aggregate supply and demand, we estimate there are approximately 3,250 taxis and 8,375 rideshare drivers operating in New Zealand, with varying levels of exclusivity to platforms. Based on an assumed mileage of 60,000km/year for taxis and 30,000km/year for ride-hailing, the services are estimated to account for 0.39% and 0.56% of total national VKT respectively, or just under 1% of total VKT combined.

8.2.3 Results - average costs

Table 8.2.1 presents costs per kilometre for ride-hailing and taxi services vis-à-vis private cars, as estimated using the PC-OC and TR-OC models. Ride-hailing and taxis cost $2.60 and $3.23 per in-service vehicle km, respectively, compared to approximately $0.70 for cars: the great majority of this difference relates to the absence of driver payments for private car use. The results imply per kilometre operating costs of ride-hailing services are approximately 20% lower than taxis. Much of this cost difference stems from higher utilisation, which reduces the labour costs per in-service vehicle kilometre.

Based on an average occupancy of 1.56 passengers (excluding the driver) per trip (consistent with estimated average occupancy for NZ cars/light vans) and an average trip length of 6.38km, we derive total per passenger trip costs of $12.24 and $15.20 for ride-hailing and taxis, respectively (NB: These figures include GST: for business-related travel, the GST component should be deducted from these numbers).

Table 8.2.1: Costs per in-service vehicle-kilometre – Taxi and Ride-hailing services vis-à-vis Private Cars

Cost components		**Car**	**RH**	**Taxi**
1) Variable operating costs	Resource	$0.26	$0.28	$0.28
	Duty	$0.11	$0.09	$0.11
2) Fixed operating costs	Resource	$0.08	$0.08	$0.04
	Duty	$0.01	$0.01	$0.00
3) Fixed Ownership Charges		$0.24	$0.11	$0.10
4) Labour/Contracting Costs			$1.34	$2.19
5) Platform and Licensing Costs			$0.42	$0.30
6) Additional Consumer Charges			$0.28	$0.20
Total Cost	**per in-service veh-km**	**$0.70**	**$2.60**	**$3.23**
	per pass-km (inc GST)	**$0.44**	**$1.92**	**$2.38**
	per pass-trip (inc GST)	**$2.86**	**$12.24**	**$15.20**

8.2.4 Results - marginal costs

While our TR-OC cost model does not include a separate module for estimating marginal costs, the marginal costs likely to be of most interest are those relating to variations in vehicle utilisation (e.g., driver hours/year) and average speeds. The marginal costs for such changes may be readily estimated by pro rata adjustments to the variable operating cost figures and/or the labour/contracting cost figures in table 8.2.1.

8.3 Micro-mobility

8.3.1 Overview

This section presents an analysis of the early experience with shared micro-mobility (scooter-based) services in New Zealand, with a primary focus on the costs of these services. The focus is on scooters defined as a “Powered Standing Scooter” for the purpose of the Society of Automotive Engineers definition and a “Powered Transport Device” under the NZTA Accessible Streets definition. These are powered by 300W motors, which typically allow average operational speeds of 7.5-10kmh, with a mean trip distance and time of around 1.3 km and 10 minutes. They are provided via dockless shared schemes in urban zones, and accessed by a smartphone app.

Micro-mobility services are relatively new to New Zealand: the services have been undergoing rapid change and growth in demand since Lime’s entry to the New Zealand market in Auckland in 2018. Several micro-mobility companies are now active in the New Zealand market, with schemes operating in Auckland, New Plymouth, Hamilton, Wellington, Christchurch, and Dunedin. User charges are typically based on a flag-fall plus a per minute charge, though certain companies also offer discounted subscription options. Rapid changes in industry structure, technological and operational characteristics, and business models through the DTCC study period have complicated our analyses.

8.3.2 Shared Micro-mobility Operation and Cost Model

This cost model ('SM-OM') was developed to provide estimates of the costs of using shared scooter services on a per kilometre and per trip basis. It comprises four major cost components:

- *Fixed Capital Expenditure* – which covers costs related to purchasing vehicles/parts and preparing them for deployment, with allowances for caps, vehicle churn, and repairability.
- *Variable Operational Expenditure* – which covers variable costs associated with operating shared scooter services, such as distributing and recharging vehicles, checking and repairing vehicles, and new user promotions and marketing activities.
- *Fixed Operating Costs* – which covers fixed costs required to run the business, including employees, general brand marketing, government relations and fees, legal expenses, insurance, technical development, vehicle, office and warehousing expenses.
- *Taxes and profit* – which covers taxes, repayment of debt and a return to investors.

8.3.3 Model results

Our main results draw on trip distribution data provided by Auckland Council. In the initial 12-month trial to November 2019, 1.78 million shared scooter trips were undertaken in the Auckland region, with an average trip distance of 1.3km, resulting in ~2.2 million person-km p.a. This represents a mode share of 0.08% of trips and 0.01% of distance travelled in the Auckland region. The weighted average trip distance was 1.32km with a duration of 10.97 minutes, giving an average speed of 7.2km per hour. Based on a pricing structure of $0.38 per minute plus an $1.00 unlock fee, this yielded a weighted average charge of $5.00 per trip, equating to $3.79/km.

These charges are assumed to cover the rental, basic liability insurance, payment processing fees as well as customer support. Table 8.3.1 shows the main cost components as a proportion of the total and on a per kilometre basis.

Table 8.3.1: Main results – cost components per kilometre to generate consumer charge

Line Item	% of total cost	$ per km
1) Fixed Capital Expenditure	20.10%	$0.76
2) Variable Operational Expenditure	43.64%	$1.65
3) Fixed Operating Expenses	19.80%	$0.75
4a) Taxes	5.40%	$0.21
4b) Profit / Repayment of shareholders	11.00%	$0.42
5) TOTAL COST	**100%**	**$3.79**

User charges varied from something over $4.00 per km for very short trips down to $3.00 per km for trips of around 5 per km. Actual user charges would vary depending on the average operating speed.

While the SM-OM model estimates the cost structure for shared micro-mobility as it existed in NZ in 2019/20, we expect technological innovations will progressively reduce costs and (given the competitive nature of the market) also user charges. Possible projections for future cost curves, in which we make assumptions on these innovations, were developed. Similar studies in Paris, where the market is somewhat further developed than in NZ, have suggested the potential mode share for such devices may approach between 10% and 21% of all person km by 2030. We also understand that WK has been assessing scenarios for future micro-mobility mode shares in the NZ context (for both owned and shared devices).

Chapter 9: Active Transport

9.1 Scope of chapter

this chapter covers the study's consideration of what we have termed 'active' transport in NZ, under two headings:

- Walking and cycling (section 9.2). These modes are considered together, as there is a large degree of commonality between them in terms of (i) assessment of the facilities and costs involved in their provision; and (ii) their effects, in terms of health impacts and environmental impacts.
- Health impacts (section 9.3). This section addresses the health impacts (for both individuals and for the public health system) of the increases in physical activity associated with active travel modes (principally walking and cycling) impaired with more sedentary modes of person travel (principally cars).

9.2 Walking and cycling

9.2.1 Overview

Walking and (e)-cycling play an essential role in New Zealand's transport system. Like many other parts of the transport system considered in this report, walking and (particularly) cycling are undergoing a period of rapid change—driven by a potent combination of emerging technologies, such as electric bicycles, and evolving policy, particularly relating to the reduction of GHG emissions from the transport sector. In their recent report, for example, the New Zealand Climate Commission recommends increasing per capita use of walking and cycling nationally by 25% and 95% respectively, as contributions to reducing NZ's carbon emissions. For these reasons, the DTCC study presents a somewhat rare and timely opportunity to investigate the financial and economic costs of walking and cycling in the New Zealand context.

This section focuses primarily on the direct costs of walking and cycling to government and users. By direct costs, we are referring to infrastructure costs incurred by government and, in the case of cycling, also operating costs incurred by users. Notably, the scope of this section excludes the benefits of walking and cycling and associated social costs, such as health cost savings: these are addressed in other sections of this report (refer sections 9.3 and 11.1 -11.4 in particular).

Our work on this topic has been constrained by: (i) the limitations of data on demand for walking and cycling, which are particularly significant given the recent/ongoing growth in cycling; and (ii) the lack of comprehensive spatial data on walking and cycling infrastructure and its costs. We have developed a cost model which may be used to understand the sensitivity of our results to the key assumptions and uncertainties.

9.2.2 Costing approach

We estimated the direct costs of walking and cycling as the sum of the following three components:

- Land costs, i.e., the estimated cost of land within the road corridor (or elsewhere) that is used exclusively to accommodate walking and cycling infrastructure,

- Capital costs, i.e., the estimated costs of constructing and maintaining walking and cycling infrastructure in the road corridor (or elsewhere), and
- Operational costs, i.e., the costs to bicycle owners of purchasing and operating bicycles (apart from time costs, which are not considered here; we also assume walking incurs zero operational costs to users).

Land costs were estimated as the product of***:***

- ○ The physical length of the walking and cycling network(s). For dedicated cycle lanes, this data is readily available from WK. For walking, we estimated the length of footpaths as a function of the length of the urban road network; and
- ○ The typical physical width of cycle lanes and paths; and.
- ○ Typical land prices (per square metre) in urban areas.

Infrastructure capital costs were estimated based on typical costs for replacing existing infrastructure (rather than providing new infrastructure). These costs were then expressed as an annualised amount, allowing for capital depreciation (or facility maintenance) and a cost of capital (4% pa in real terms).

Operational costs (cycling) comprise two elements:

- ○ the capital costs of bicycle/e-bike purchase, annualised over typical bicycle lives; and
- ○ operating and maintenance costs, based on case study information and allowing for additional electricity and maintenance costs for e-bikes.

The resultant costs were then normalised as appropriate, to provide results on an average cost per person km or person trip basis.

9.2.3 Costing results

9.2.3.1 Total costs

Direct economic costs to government totalled $1.50 billion pa, with land costs comprising 84% and capital costs 16%. 89% of this total related to footpaths, 11% to cycle-paths. 96% related to paths within urban areas.

9.2.3.2 Average costs

Table 9.2.1 shows the average direct economic costs (to government plus users) associated with use of walking and cycling facilities. In each case, the user costs are estimated at 3.4c/km for cycling, close to zero for walking.

Table 9.2.1: Average direct economic costs per person kilometre travelled

Location	Costs	Walk	Cycle
Urban	Government	$2.09	$0.56
	User	-	$0.34
	Total	$2.09	$0.90
Rural	Government	$1.14	$0.68
	User	-	$0.34
	Total	$1.14	$1.02

9.2.3.3 Marginal costs

The user marginal costs of walking are close to zero; the user marginal costs for cycling are taken as equal to the average maintenance costs, approximately 13c/km.

9.2.4 Comment on land valuation

A significant discrepancy has been identified between the unit land valuations used in this section for walking/cycling and the unit valuations used (by WK) for valuation of the road infrastructure, in particular the local road valuations (refer section 4.2 of this report). The unit values used by WK are very much lower.

Given that the land values in this section represent 84% of the direct economic costs to government associated with walking and cycling infrastructure, we undertook various sensitivity tests on our results.

We suggest that investigation of this apparent discrepancy should be given high priority in any follow-on work to DTCC.

9.3 Health impacts of active transport

9.3.1 Overview

This section addresses the health benefits (to both individuals and the health system) of increases in physical activity associated with greater use of ‘active‘ travel modes (principally walking and cycling) over more sedentary modes (principally cars). It focuses on public health impacts associated with physical activity, while noting that air pollution and injury-related costs are covered elsewhere in this report.

Transport impacts on public health through multiple pathways including through road traffic crashes, air pollution, noise and physical activity. These pathways impact a wide range of health outcomes - including injury, type 2 diabetes, respiratory diseases, cardiovascular diseases, selected cancers and mental health. The wide range of health impacts of transport results in costs to individuals, government and wider society. Estimates of the costs associated with the public health impacts are important to consider in assessments of the costs associated with the transport system and its use.

The ‘base case’ for our assessment is travel by means that involves no or minimal physical activity (often taken as travel by car). Our assessment compares the health-related economic cost savings (benefits) of using other (more active) transport modes with the ‘base case’ economic costs.

9.3.2 Methodology

An established multi-state life table model was applied to estimate the health impacts and health system savings associated with different transport modes. As the focus was on physical activity, it was not appropriate to make assumptions about physical activity forgone by the use of physically inactive transport modes: rather, the assessment only considered modes that would involve some physical activity and thus result in an increase in overall physical activity. The values derived are therefore more accurately described as benefits (economic cost savings) resulting from an increase in physical activity, rather than economic costs associated with reduced physical activity.

A probabilistic sampling framework was developed to run through thousands of different transport scenarios and estimate the individual health benefits (cost savings) and public health system cost impacts of each scenario. The results from scenario modelling were used to derive average physical activity-related health cost savings (or benefits) associated with different modes of transport on a per person kilometre basis. Estimates for modes not explicitly considered in the model (e.g., e-bikes, scooters, public transport) were obtained by scaling results from modelled modes, where there was evidence that these other modes resulted in changes in physical activity. For all modes covered, cost savings (benefits) were separated into direct costs savings to the health system, and individual socio-economic benefits associated with individual level changes in health status. The latter was based on using a Value of a Statistical Life (VoSL) approach to value a Quality-Adjusted Life Year (QALY). The Ministry of Transport VoSL for 2018 ($4.34 million) was applied, consistent with the 2018/19 base year of the analysis.

9.3.3 Results and application

It was estimated that walking results in 0.013 QALYs gained per 1,000km walked (relative to car travel), and cycling is associated with approximately half this health gain of walking per km travelled. Differences in the health gains across different modes represent differences in the effort required to travel by different modes (and therefore the amount of physical activity that is involved per kilometre travelled). Results reflect the total health gain expected over the life course of the population. Through monetising these health gains, the health-related benefits to individuals per kilometre of walking were estimated at $2.73 and per kilometre of cycling at $1.51 (with 4% discount rate applied).

In addition to these benefits to the individuals concerned, travelling by active modes of transport, or modes that are associated with active travel, would result in cost-savings to the health system. Increased physical activity that results from active transport results in reduced incidence of non-communicable diseases (e.g., cardiovascular disease, selected cancers). This in turn results in savings to the healthcare system, even after accounting for increases in costs associated with increased longevity. Active travel involving walking or cycling results in net health system cost savings of $0.155 per kilometre walked and savings of $0.088 per kilometre cycled: these figures are additional to the above values representing the socio-economic health benefits of walking and cycling to participants.

Taken together, these figures represent a reduction in economic costs (or a net economic benefit) to society of $2.885 per km walked or $1.598 per km cycled, relative to no travel or to travel by car or other modes which do not involve significant physical activity.

As an illustrated application of these benefit figures, the health-related benefits were assessed if 20% of current NZ person kilometres of car travel were to switch to active modes, with 75% of these switching to walking and 25% to cycling (giving a weighted average benefit of $2.563 per person km). Given the total NZ car/light vehicle travel of 45.4 billion vehicle km pa at an average car occupancy of 1.56 persons (giving a total of 70.8-billion-person km pa), a 20% modal switch would represent 14.16 billion person kilometres pa. At the weighted average benefit rate ($2.563/person km), the annual economic health benefits would be valued at $36.3 billion pa: this is a very large amount relative to almost all the other cost and benefit estimates derived elsewhere in this study. Of course, in overall transport economic terms, these health benefits may well be partially (or totally) offset by increased travel times - although such increases seem likely to be minimised (in urban areas in particular) through the use of e-bikes.

Chapter 10: Coastal Shipping

10.1 Scope of chapter

This chapter covers the NZ coastal shipping 'sector', in two main sections:

- Domestic sea freight (section 10.2)
- Cook Strait ferry services - which provide for both passenger and freight movements (section 10.3).

A further section (10.4) provides brief comments on maritime accidents associated with the sector and on the sector's environmental impacts (which are set out in more detail in chapter 11).

10.2 Domestic Sea Freight

10.2.1 Scope

Coastal shipping is a niche provider in the NZ domestic freight (and passenger) market. This section examines the costs and charges associated with providing shipping capacity to NZ's key coastal shipping freight markets: cement (dry bulk), petroleum (liquid bulk) and containers.

Coastal and international trade is focussed on 8 key commercial ports. The largest, Tauranga, serves 25% of all cargo ship visits, 31% of NZ's international trade, and 43% of the container trade. The coastal shipping sector operates on a fully commercial basis. Shipping capacity is provided by competing private domestic and foreign operators, while ports are commercial enterprises run by local authorities.

NZ's domestic cargo-carrying capability is provided by 7 domestic ships and numerous foreign ships, all of which nominally compete against road and rail.

10.2.2 Market overview

Coastal shipping carried an estimated 5.2 million tonnes ("mt") of cargo in 2018/19, representing less than 2% of the domestic freight task. Its market share in terms of tonne kms (9.7 billion ntkm) is much greater, at 13.2%, reflecting its relatively long average haul length (890 km)[72].

The 5.2 mt coastal shipping freight task is made up of 2.5 mt petroleum products (liquid bulk), 1.1 mt cement (dry bulk), 0.25mt of various other bulk cargos (break, dry and liquid) and an estimated 1.1 mt of containerised cargoes.

Container ships carried 270,000 TEU of domestic containers along the NZ coast in 2019, in addition to 169,000 TEU of transhipments[73]. 129,000 TEU of those domestic containers (48%) were loaded, with an estimated cargo weight of 1.1 million tonnes (assuming 8.9t/TEU, as derived from imported containers). Transhipment containers, 95% being full, accounted for an additional estimated 1.56 mt. The coastal shipping of containers (domestic and transhipment) competes directly with long-haul road and rail transport. The sole domestic container ship (the Moana Chief) directly contests the coastal container trade with foreign ships – and has achieved a 25% market share of this trade.

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[72] Based on National Freight Demand Study 2017/18 ("NFDS"), adjusted for 2018/19 data

[73] Derived from Freight Information Gathering System ("FIGS") database

NZ ports served over 7000 ship visits in 2018/19, with the 8 key ports handling 83% of the 5500 cargo ship visits. Container ships accounted for 55% of those visits, bulk ships almost 30%, while tankers and vehicle ships shared the balance. This ship traffic is primarily serving international trade, with domestic coastal cargo accounting for less than 10% of the total handled by NZ ports. 410,000 TEU domestic containers were moved along the coast, each being handled by both a loading and a discharge port and representing 25% of port throughput.

Coastal shipping competes most effectively in the long-haul domestic freight market, with its average haul distance of 890km being materially higher than rail at 230km and road at 90km (NFDS). The national distribution of just two commodities, petroleum and cement, accounts for 75% of the coastal shipping task, with each forming part of vertically integrated (uncontested) supply chains. COLL operates two dedicated ships distributing 2.5 million tonnes of petroleum from Marsden Point to all NZ ports[74]. Similarly, two competing cement suppliers (Golden Bay Cement and Holcim) collectively distribute 1.4 million tonnes of cement[75] from Whangarei and Timaru respectively on their own ships. All other bulk cargo amounts to less than 5% of the coastal shipping freight task, while containers make up the remaining 20%.

A changing market environment has seen the decline of domestic shipping over many years. Step changes have arisen from key events. Key were the establishment of the Cook Strait RORO ferries in 1962, which absorbed most inter-island traffic, while the Maritime Transport Act 1994 allowed foreign ships to carry domestic cargo (cabotage), which quickly captured a major part of the rapidly growing container trade.

Domestic ships operate at significant disadvantage to global players. First, the small coastal freight market denies domestic operators the scale economies able to be achieved by global shipping operators, which are also able to utilise available ship capacity to carry domestic cargo at minimal marginal cost. Second, bunkers (ship fuel) cost 30% more in NZ than in global markets[76], a material disadvantage to domestic ships given bunkers account for about 40% of total ship operating costs[77]. Third, domestic ships must pay the NZ Emissions Trading Scheme (ETS) levies on bunkers (adding a 15% premium) whereas foreign ships are exempt[78]. Additionally, most components of ship operating costs are higher in NZ. Crewing costs are up to triple the level of global seafarers (higher salaries, more shore leave), consumables and maintenance are broadly double while, in the absence of suitable facilities in NZ, domestic ships must travel far for dry-dock inspections.

10.2.3 Total cost assessment

Our analysis has been based primarily on comprehensive official datasets, notably the Ministry of Transport's National Freight Demands Study 2019 ("NFDS") and its Freight Information Gathering System ("FIGS") database. Publications and datasets from Statistics NZ and key industry stakeholders such as NZ ports added considerable detail. Shipping is a competitive and volatile sector, with limited formal information available on costs and prices: accordingly, we have relied on respected international studies, notably Drewry's Ship Operating Cost Review 2018/19 and ASX Marine's Alphaliner database. With kind inputs from key NZ stakeholders, these global insights and local knowledge have been

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[74] FIGS data

[75] Derived principally from Golden Bay Cement and Holcim announcements

[76] Bunkerworld and personal comments by Z-Energy

[77] Drewry Ship Operating Costs Annual Review and Forecast 2019/20 ("Drewry")

[78] United Nations Kyoto Protocol 2005 and International Maritime Organization MARPOL Convention

adjusted to better reflect the domestic shipping sector, allowing for both the smaller ship sizes and the higher domestic cost structures.

The two key domestic coastal bulk trades, petroleum and cement, are part of uncontested integrated supply chains, with little insight being available into the breakdown of cost components (raw materials, manufacturing, distribution etc) of the final product. Containers in contrast represent the key contestable coastal trade, with their shipping costs being a more discrete, identifiable component. Accordingly, containers are the focus of our financial modelling, which has then been extended to the bulk trades.

Ship-related costs comprise capital costs (the ship itself), ship operating costs (including labour) and bunker costs (fuel for the journey). Port charges are divided between 'wet' charges (levied on the ship) and 'dry' charges (levied on any cargo loaded or discharged). Drewry assessed ship costs across a range of ship types and sizes (most often larger than those operating in NZ), with scale economies apparent for larger ships. Similarly, port wet charges reflected scale economies on ship size, although dry charges were fixed according to cargo type (for containers: TEU or FEU, full or empty, dry or reefer). Informed assumptions were made to allocate the known cargo mix to the various ships and routes, so allowing for ship costs to be unitised as $/tonne or $/TEU. Domestic ships need to recover their costs solely over the coastal cargo they carry, whereas foreign cargo ships (principally container ships) can spread the costs of core import and export cargoes by choosing to carry coastal cargo.

The total costs (including normal profit margins) associated with the 2018/19 coastal shipping domestic transport task (5.2 million tonnes, 4.7 billion ntkm, as above) were some $225 million pa. This equates to an average of approximately $45/tonne (or 4.1c/ntkm) for containerised freight, $40/tonne (or 6.4c/ntkm) for dry bulk freight (such as cement) and $45/tonne (or 4.5c/ntkm) for liquid bulk freight (such as petroleum).

10.2.4 Marginal cost assessment

For an industry where capacity can only be added in relatively large increments, it is difficult to provide a single measure of marginal cost that is useful for policymakers. Both ship owners and ports operate with a degree of slack to provide flexibility to meet varying customer requirements and to have the ability to absorb delays due to weather and unexpected events. Thus, in the very short run, there is generally some spare ship, infrastructure and port worker capacity on the New Zealand coast. As a consequence, the marginal cost in the strictest sense is often close to zero (this is also likely to be the case for other modes of transport). However, for the policy maker, if we simply report that there is spare capacity at the margin in ships and trains so the marginal cost in each case is close to zero, this may be interesting but is unhelpful. Of greater interest is an assessment of what increment in demand may necessitate investment to add capacity, and so increase marginal costs in the longer run.

When considering issues relating to cabotage, we could consider the carriage of domestic containers as the marginal activity. In this case we could make the assumption that the foreign ship itinerary is fixed by the need to service its international cargo. The incremental cost of handling domestic containers comprises the direct port costs and the in-port costs of ships transferring cargo. Per container, the latter increase with ship size. The marginal cost is estimated to be $120 per TEU per port or $240 in total for both domestic and international ships, of which around $220 is port handling costs and $20 is ship costs.

However foreign shipping has (in theory at least) the option of making a single NZ port call and aggregating/dispersing cargo by land transport, in which case the entire coastal operation becomes a marginal activity. Viewed in this light, the appropriate cost to use would include the steaming cost for foreign ships on the NZ coast. This increases the marginal cost by 3.5 cents/TEU-km and 0.9 cents/TEU-km for domestic and international ships respectively. This is an additional $50 for the Moana Chief or $25 for a 4000 TEU international vessel between Auckland and Lyttelton. If we calculate the costs on this basis, this will be more helpful in the context of making policy decisions such as “should we invest in port facilities to handle international cargo at Napier”.

The ports also appear to have spare capacity, but this is not so significant when we compare the utilisation with the industry norm of 60% utilisation, above which risks of ship delays put pressure on ports to increase capacity. This is because there is a marginal (externality) cost associated with port calls since one ship taking longer to load/unload due to the marginal container potentially delays subsequent port users. This cost depends on the utilisation of the current infrastructure and is estimated to be as high as $5 per TEU for Auckland and as low as $1.50 per TEU for Wellington.

The long run marginal port cost will include the capital costs of additional cranes, berths and other infrastructure. Based on expected capital costs and likely utilisation, this is estimated to be $4 per TEU for new berths and $4.50 per TEU for additional cranes. Port capacity should be expanded if this cost is less than the marginal cost derived above. We estimate that this will be the case if either crane utilisation exceeds 50% or berth utilisation exceeds 45% of nominal capacity. This compares with the industry norm of 60% of capacity.

10.3 Cook Strait Ferry Services

10.3.1 Overview

The Cook Strait ferry services form a vital part of New Zealand’s transport infrastructure, providing a reliable “land bridge” between North and South Islands for passengers, cars, commercial vehicles and trains. Currently two operators, state-owned KiwiRail and private StraitNZ, collectively operate 5 ROPAX ferries providing 6300 one-way sailings annually.

10.3.2 Methodology and Information Sources

Our analyses of the Cook Strait ferry services have been informed by public data sources, with cost estimates based largely on international proxies.

KiwiRail’s Annual Reports and website provide complete, although high level, operational and financial information for their “Interislander” ferry operations.

StraitNZ, owner of “Bluebridge”, is a private company and not required to publicly disclose any commercial data: it declined to provide information or commentary for the study. We have principally relied on media statements reviewing a sales flyer from StraitNZ’s then-owner, CPE Capital.

As part of the study, Rockpoint (the DTCC consultant on shipping aspects) had access to the Ministry of Transport’s subscription to Drewry’s “Ship Operating Costs Annual Review and Forecast 2019/20” (“Drewry”) which provides a detailed global cost breakdown for most commercial ship categories, including RORO. Rockpoint also subscribes to ASXMarine’s Alphaliner shipping database for information on fleets, schedules, and ship pricing.

Public sources and websites where available were utilised extensively including NZ government agencies (MoT, MNZ, Treasury, StatsNZ and WK), global agencies (such as IMO, WTO, IEA), and sites providing databases, commentary and monitoring of world shipping and bunker pricing.

10.3.3 Current Operations

In a global context, the current Cook Strait Roll-on Roll-Off Passenger (ROPAX) ferries are considered mid-sized, and at average 21 years, relatively old. Since KiwiRail (then NZ Rail Department) established its Interislander ROPAX operations in 1962, the role of pre-existing coastal shipping on the Cook Strait route was largely supplanted. Interislander first faced Cook Strait competition in 1992 when StraitNZ introduced first a small livestock carrier, then a series of non-passenger RORO ships from 1995, before initiating direct ROPAX competition in 2002, with the launching of its 'Bluebridge' brand. Bluebridge now claims 56% of the key commercial vehicle market on the route.

Wellington (CentrePort) and Picton (Port Marlborough) provide port terminals to the two ferry operators. CentrePort's Kaiwharawhara terminal was established in 1962, serving Interislander. A new terminal at Glasgow Wharf was built to serve Bluebridge. Port Marlborough similarly provides separate terminals for the two ferry operators.

The ports collectively report 6300 one-way sailings annually, with Interislander providing 3700 sailings, and Bluebridge 2600. Sailing schedules are adjusted slightly to reflect seasonal demand patterns, with extra sailings over the peak summer season, and maintenance scheduled for off-peak times of year. These schedules allocate 3.5 hours to each sailing, implying a transit speed of 16-20 knots, with 2 hours turnaround time. This indicates ship utilisation at a creditable 79% ship (the balance allowing for repairs and maintenance, downtime and surveys, scheduled during off-peak times of the year).

The ferry operators' booking websites provide an insight into pricing. Competition keeps pricing closely aligned.

10.3.4 Financial Assessment

Both Interislander and Bluebridge operate booking websites from which passenger, car and small truck rates can be derived. While neither disclose pricing for larger commercial vehicles, these can be deduced by deducting car and passenger revenue from total revenues, to calculate an approximate charge per lane-m occupied. Our analysis suggests Interislander generates $60m pa from commercial vehicles (being 44% of third-party revenues), at a calculated rate of $50/lane-m. We assume rail wagons are charged at a small premium, nominally $60/lane-m, to generate $34 million of related-party revenues for KiwiRail.

Bluebridge has steadily gained market share in commercial vehicles (from 47% to a claimed 56%) over the last decade. Given ship schedules are similar, we assume StraitNZ prices at a modest discount to Interislander – we have assumed $45/lane-m for commercial vehicles – and would account for $69m (67%) of its revenues. Total Bluebridge revenues were $102m in 2019, and $120m when projecting forward to 2021 (implying that StraitNZ's non-ferry operations generate the balance of the $175m total cited in CPE's StraitNZ sales flyer).

Drewry's 2019 Ship Operating Cost review provides the core data for our cost analysis. This confirms that manning accounts to 50-55% of ship operating costs (excluding bunkers). As highlighted earlier (section 10.2), costs applying in NZ are materially higher than prevailing prices internationally, with manning 2.1 times global rates, and overall 1.6 times. Bunkering, which accounts for half the total cost of deploying a ship (ship operating costs plus bunkers), is 1.5 times the prices available in Asia.

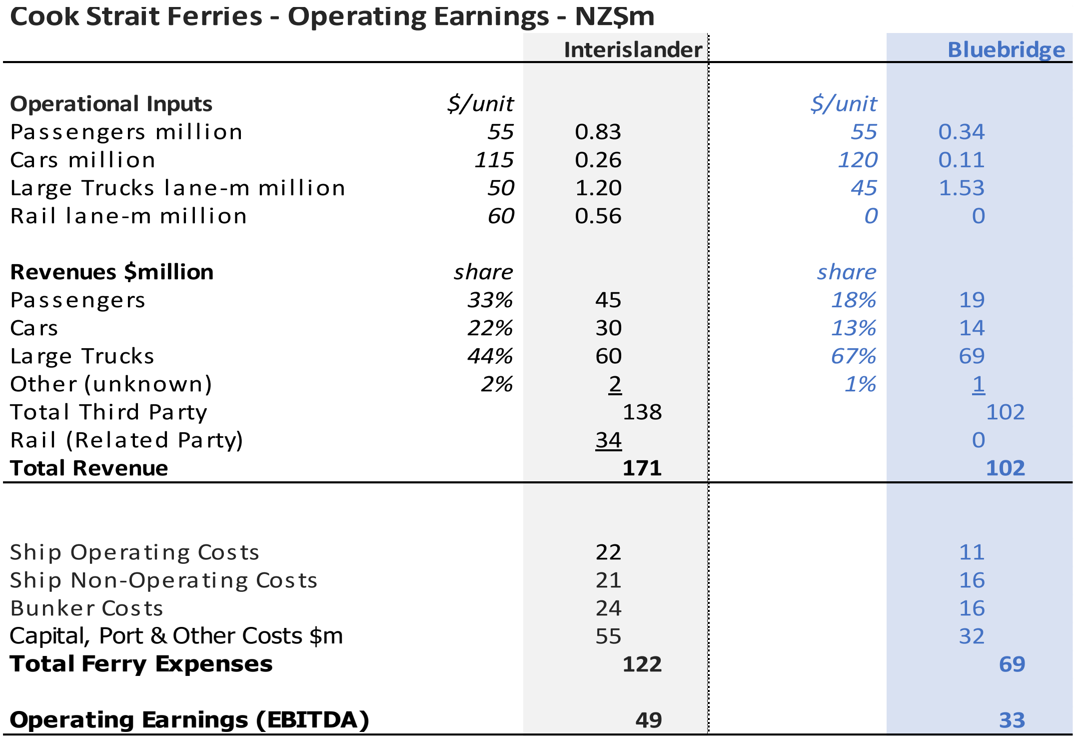
Capital charges reflect the costs of owning and financing long-term assets over their lifetime. KiwiRail's annual reports disclose Book Value and Depreciation for its ships, the key (but not only) assets of the Interislander. Bluebridge has made no public disclosures on the values of its ships, although in early 2015 the vendor of *Strait Feronia* recorded its sale price (to Bluebridge) as EUR23m (NZ$35m).

While NZ ports are required to publish annual accounts and their tariffs, no public information was available on ferry terminal charges. The infrastructure provided is largely owned by the ports, although KiwiRail does own some land and buildings in Wellington.

10.3.5 Conclusions

Our financial summary (refer table 10.3.1) provides our best estimates based on incomplete data. Operational data drives our revenue calculations, while costs cover the ship operating, ship non-operating, bunker, port and capital costs. Our modelling estimates a 2019 operating profit (EBITDA) of $49m for Interislander and $33m for Bluebridge.

Table 10.3.1: Cook Strait Ferries Operations and Financial Summary (2018/19)



Cook Strait Ferries - Operating Earnings - NZ$m

		Interislander		Bluebridge
Operational Inputs	*$/unit*		*$/unit*	
Passengers million	*55*	0.83	*55*	0.34
Cars million	*115*	0.26	*120*	0.11
Large Trucks lane-m million	*50*	1.20	*45*	1.53
Rail lane-m million	*60*	0.56	*0*	0
Revenues $million	*share*		*share*	
Passengers	*33%*	45	*18%*	19
Cars	*22%*	30	*13%*	14
Large Trucks	*44%*	60	*67%*	69
Other (unknown)	*2%*	2	*1%*	1
Total Third Party		138		102
Rail (Related Party)		34		0
Total Revenue		**171**		**102**
Ship Operating Costs		22		11
Ship Non-Operating Costs		21		16
Bunker Costs		24		16
Capital, Port & Other Costs $m		55		32
Total Ferry Expenses		**122**		**69**
Operating Earnings (EBITDA)		**49**		**33**

KiwiRail's financial statements reveal that it depreciates its ships on a straight line (historic cost) basis over 20 years, consistent with the typical observed lifespan of commercial ships. As at June 2019, the Net Book Value for its ships stood at $136m ($256m original cost less $120m accumulated depreciation), with an annual depreciation charge of $31m. With the KiwiRail ferries averaging 21 years old, reliability has become an issue (*Kaiarahi* is currently out of commission with a "catastrophically" damaged gearbox), diminishing the fleet's economic value. When KiwiRail's new ROPAX ferries arrive in 2025, Interislander's existing fleet will have minimal residua can l market value.

The Cook Strait ferry operations will be transformed following KiwiRail's disclosure of a government-approved $1.45 billion ferry investment programme, which comprises two new larger ROPAX ferries ($551 million) due in 2025/26, coinciding with the redevelopment of both Kaiwharawhara and Waitohi ferry terminals and infrastructure required to accommodate the new ferries. Bluebridge will share the Kaiwharawhara terminal while it is expected to continue using its existing Picton facilities.

Competition between the two Cook Strait ferry operators is expected to remain strong, with prospects of other ship operators (such as Move Logistics) providing additional shipping links between North and South Islands. While existing public data has proved adequate for this initial analysis, commercial considerations seem likely to continue to discourage competing Cook Strait ferry operators from providing additional data in the foreseeable future.

10.4 Maritime Accident and Environmental Aspects

10.4.1 Maritime accident summary

Data on maritime and port accidents and incidents in NZ is collected by Maritime NZ (for accidents at sea) and by each of the port authorities (for accidents within port areas). Details are given in WP C14: Coastal Shipping (Appendix G).

Accident rates for the ports/maritime sector appear to be low relative to those in other parts of the domestic transport sector, although noting that there are considerable difficulties in making inter-modal comparisons. For example, in recent years the port- based accident rates for the NZ coastal and pax/non-pax maritime sub-sectors (which are the most relevant to the scope of this chapter) have averaged 3-4 fatalities and some 45 lost time injuries per year.

10.4.2 Environmental impacts of the maritime sector

These are summarised in Chapter 11, in a form that facilitates comparisons across the various domestic transport sub-sectors.

Chapter 11: Environmental Impacts

11.1 Scope of chapter

This chapter provides our absolute and comparative appraisal of the environmental impacts of the domestic transport modes covered in the study, in three main sections:

- Local and global (GHG) emissions - section 11.2
- Noise impacts - section 11.3
- Impacts on biodiversity and Biosecurity - section 11.4.

11.2 Local and global emissions

11.2.1 Air pollutants associated with domestic transport emissions -- overview

The domestic transport sector generates air emissions, principally through the combustion of fossil fuels. These emissions are typically split into air quality pollutants (which impact locally) and greenhouse gas emissions (which impact globally).

A summary of these pollutants and their features is given in table 11.2.1.

Air quality pollutants cause adverse human health effects, ranging from increased morbidity (illness and disease) to increased mortality (loss of life). The effects depend on the pollutant, its concentration and the length of exposure – they may be either acute (short-term) or chronic (long-term).

Greenhouse gases (GHGs) are so-called because they contribute to global warming and climate change. GHGs can be short-lived, with an atmospheric lifetime from days to 15 years (e.g., BC and CH4), or long-lived with typical lifetimes of more than 100 years (e.g., CO2). For ease of comparison, GHGs are typically expressed as CO2 equivalents (CO2e), which is the amount of CO2 which would have the equivalent global warming impact over 100 years.

Table 11.2.1: Summary of local air-quality pollutants and climate pollutants (greenhouse gases)

Pollutant	**Features**
***Air quality pollutants*:**	
Particulate matter (PM)	*Particulate matter (smaller than 10µm or 2.5µm) - results primarily from diesel fuel combustion, brake/tyre wear and road dust.
Nitrogen oxides (NOx)	*Emitted primarily from diesel and petrol fuel combustion, with nitrogen dioxide (NO2) the pollutant of most concern,
Sulphur dioxide (SO2)	*Previously (until 2009) a primary source was the sulphur level in motor diesel, but this has now been reduced to very low levels. Still associated with combustion of marine transport fuels (but principally coastal freighters rather than local ferries).
Volatile organic compounds (VOC)	*Result from evaporation of fuel in engines and re-fuelling systems as well as fuel combustion.
Carbon monoxide (CO)	*Associated with incomplete combustion of petrol. Now a lesser concern as most petrol vehicles fitted with catalytic converters.

Greenhouse gases (GHG):	
Carbon dioxide (CO2)	*Released from combustion of all fossil fuels (especially mineral-based petrol and diesel). Combustion of renewable fuels also produces CO2, but the net effect is considered zero as the CO2 is then recaptured in the production of the renewable fuels.
Methane (CH4)	*Commonly associated with incomplete combustion and fuel system leaks in natural gas-fuelled vehicles
Nitrous oxide (N2O)	*Also associated with fossil fuel consumption. Note - different to NO2 an air quality pollutant.
Black carbon (BC)	*Essentially fine particulate matter (PM2.5 and smaller), which is produced primarily from diesel combustion.

11.2.2 Assessment approach

This section provides a brief overview of the four main steps involved in the estimation and valuation of air-quality and greenhouse gas emissions.

11.2.2.1 Approach adopted

One of two approaches is commonly adopted in estimating emissions - a ‘bottom-up’ approach (i.e., where emissions are estimated locally and then aggregated to regional and national totals) or a ‘top-down’ approach (i.e., where emissions are estimated nationally and disaggregated to local levels by pro-rating by population or some other relative activity indicator). For this study, given data limitations, we estimated emissions for some sectors by ‘bottom-up’ methods (e.g., road transport exhaust emissions) but mostly relied on ‘top-down’ methods with regional or urban/rural splits made on the basis of local activity information.

11.2.2.2 Key data sources

In most cases our analyses relied on national-level transport fleet composition, fuel use and activity data reported by various agencies. For example:

- 2019 New Zealand Vehicle Fleet Statistics (MoT 2020) for national vehicle kilometres travelled (VKT) data
- Air traffic movement to March 2020 (Airways Ltd 2020) for domestic aircraft movements by airport
- Performance of public transport services (NZTA 2020) for activity rates for all modes of urban public transport (bus, rail and ferry) by region.

We used emissions factors from New Zealand sources where possible, supplemented with factors that are relevant to New Zealand transport fleet from internationally published databases.

We also cross-checked our final estimates for consistency with those reported in:

- National Air Emissions Inventory for 2015 (Metcalfe and Sridhar, 2018) which provides estimated emissions of PM10, PM2.5, CO, NOx and SOx for all the main domestic transport modes.
- New Zealand’s Greenhouse Gas Emissions Inventory 1990 – 2018 (MfE, 2020).

11.2.2.3 Spatial disaggregation

Spatial disaggregation of the national figures was seen as important, particularly between urban and rural areas, as the impacts of air-quality pollutants are almost entirely linked to the relevant populations in adjacent areas (whereas the GHG impacts are independent of local populations). Given this, we disaggregated the data from the National Air Emissions Inventory between urban areas (defined as all settlements with more than 1000 residents) and rural (all other) areas.[79]

11.2.2.4 Temporal dimension

All emissions estimates were undertaken for the base period of FY 2018/19, averaging base data for the 2018 and 2019 calendar years where it was not available for the 2018/19 financial year.

11.2.3 Cost factors and their application

Emissions to air, associated with air quality pollutants, cause adverse impacts on society through illness, lost productivity, increased hospitalization, premature mortality etc; and GHG emissions typically cause adverse impacts through extremes in climate ('global warming') affecting human health, as well as built and natural environments (both in terms of biodiversity and productivity).

The social costs resulting from these effects can be calculated most easily by multiplying the quantity of emissions (in grams or tonnes of the pollutant) by a unit damage cost ($/tonne) for each pollutant. Damage costs are a way to value changes in emissions so that the benefits to society of a change in policy/operation can be compared against the cost of implementing the change. They can also be used to compare a range of options to see which will result in the best overall outcome.

11.2.3.1 Emissions damage costs developed for DTCC

The Waka Kotahi 'Monetised Benefits and Costs Manual' (MBCM) contains a set of damage cost values covering the main road transport-related air pollutants. However, these were of somewhat limited value for DTCC purposes, particularly as they do not distinguish between values for urban and rural situations. One of the key objectives of the latest 'Health and Air Pollution in New Zealand' (HAPINZ 3.0) study has been to develop NZ-specific damage cost values, distinguishing between urban and rural situations. While the completion of the HAPINZ study has been delayed (primarily due to Covid-19), we were able to access the study's preliminary findings (particularly relating to the ratio of urban vs rural damage costs).

Based on the HAPINZ results and other 'best estimate' published damage costs, we were able to develop a modified set of unit damage cost values for the main pollutants, with separate values for urban and rural situations, and adjusted to the base date of June 2019. These rates are shown in table 11.2.2.[80]

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[79] In understanding the incidence of emissions, we considered that this urban vs rural disaggregation was of greater importance than any regional disaggregation. However, we recognise that this urban vs rural disaggregation is still relatively crude: it could potentially be improved by recognising that the costs imposed by air quality pollutants (e.g., per tonne) are sensitive to the population density in the area or alongside the transport route concerned.

[80] The damage costs shown in table 11.2.2 for urban situations are generally similar to those in MBCM (allowing for inflationary effects); but MBCM does not include any values for rural situations.

Table 11.2.2: Adjusted damage costs used in the DTCC emissions assessment (June 2019 prices)

Pollutant	Costs in NZ$/tonne Urban	Costs in NZ$/tonne Rural
PM_{10}	$503,346	$38,480
SO_2	$36,491	$2,790
NO_X	$17,887	$1,367
VOC	$1,433	$110
CO_2e	$88	$88
CO	$4.52	$0.35

The table 11.2.2 cost rates have been applied for all modes throughout the DTCC environmental impact analyses. We have also assumed that:

- all environmental costs are additive (i.e., there is no double-counting between different pollutants); and
- the rates given may be applied to marginal situations as well as 'average' situations (i.e., the marginal environmental costs are equal to the average environmental costs).[81]

11.2.4 Consideration of 'whole of life' impacts

Typically (and in the assessment above), the impacts assessed are limited to those air quality and GHG emissions resulting from the direct use (only) of the various modes in their typical situations - in other words they relate to fuel combustion, brake and tyre wear, and road abrasion (dust from sealed and unsealed roads). However, there are other 'upstream' and 'downstream' processes related to transport that also lead to negative external effects. Taking a *life-cycle view*, the energy production, the vehicle and infrastructure production, maintenance and 'end-of-life' disposal (scrappage) are all associated with additional air pollutants and greenhouse gases.

Typically, assessments focus on 'tank-to-wheel' (TTW) emissions only. More holistic assessments, which are becoming increasingly common, include 'well-to-tank' (WTT) emissions also, resulting in a 'well-to-wheel' (WTW) assessment: this covers all the emissions associated with generating a given amount of fuel or energy and delivering it to the transport mode which then uses it. Typical WTW/TTW GHG emissions ratios (and their resultant damage costs using the same figures in costs/tonne from table 11.2.2) are around 1.125 for petrol, 1.170 for diesel[82], but comparable ratios for AQ emissions are unknown. Less information is available about GHG emissions associated with downstream processes, such as vehicle disposal/scrappage, although it would be expected that any 'mark-up' on the WTW GHG emission costs would be less than the 1.125 and 1.170 factors above.

11.2.5 Results

11.2.5.1 Overview

A summary of the DTCC results for environmental damage costs relating to transport emissions is given in table 11.2.3 (greenhouse gas emissions – WTW basis) and table 11.2.4 (air-quality emissions – TTW

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[81] The DTCC WP D4 (section 2.2.2) discusses these and related assumptions in more detail.
[82] Refer to WP D4, Table 2.3 for further details.

basis only). Each table is split between urban and rural areas, between person transport and freight transport, and further sub-divided between transport modes[83].

In each case, the tables (columns) show:

- Total annual damage costs ($m)
- Average damage costs per person km (c/pk) for person travel; and average costs per net tonne km (c/ntk) for freight transport.

The cost/vehicle km metric is commonly used throughout the transport sector as a useful measure of the relative costs for different modes, in different circumstances etc. Its main limitation is that it takes no account of the differences in transport capacity between different vehicles (e.g., comparing a 4-seater car with a 40-seater bus). More useful metrics allow for the different capacities of different vehicle

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[83] Note that walking and cycling modes are not included in these tables, on the basis that the emissions involved for these modes are zero or negligible.

Table 11.2.3: Total and normalised Greenhouse Gas (GHG) emissions costs (WTW basis) -- all NZ transport modes, 2018/19. (All costs in June 2019 prices).

Mode	Total costs -$M pa			Average (normalised) costs - c/pk, c/ntk		
	Urban	Rural	NZ Total	Urban	Rural	NZ Total
Person transport	**$380**	**$604**	**$984**	**1.3**	**1.6**	**1.5**
Passenger car	**$333**	**$508**	**$841**	**1.5**	**1.5**	**1.5**
Coach	$0.8	$2.9	**$3.7**	0.7	**0.7**	**0.7**
Other bus	$1.7	$5.8	**$7.5**	**0.6**	**0.6**	**0.8**
Motorcycle	$1.4	$2.2	**$3.6**	**0.9**	**0.9**	**0.9**
Long-distance rail	$0.03	$0.13	**$0.2**	**0.1**	**0.1**	**0.1**
Domestic aviation	$22	$81	**$103**	0.4	5.1	1.4
Urban bus	$16	-	**$16**	**1.6**	--	**1.6**
School bus	-	$3.9	**$3.9**	--	**1.0**	**1.0**
Urban rail	$1.0	-	**$1.0**	**0.2**	--	**0.2**
Urban ferry	$3.7	-	**$3.7**	**4.1**	--	**4.1**
Freight transport	**$192**	**$500**	**$691**	**1.6**	**1.8**	**1.8**
LCV	**$120**	**$183**	**$303**	**6.6**	**6.6**	**6.6**
MCV	$11	$37	**$48**	**2.2**	**2.2**	**2.2**
HCV	**$55**	**$189**	**$244**	**1.0**	**1.0**	**1.0**
Electric locomotive	$0.02	$0.1	**$0.1**	**0.1**	**0.07**	**0.07**
Diesel locomotive	$2.7	$10	**$13**	**0.4**	**0.3**	**0.4**
Coastal freighter	$3.1	$81	**$84**	**0.1**	**6.5**	**1.6**
Total ($M)	**$572**	**$1,103**	**$1,676**			

Table 11.2.4: Total and normalised Air Quality emissions costs (TTW basis) -- all NZ transport modes, 2018/19. (All costs in June 2019 prices).

Mode	Total costs -$M pa			Average (normalised) costs -c/pk, c/ntk		
	Urban	Rural	NZ Total	Urban	Rural	NZ Total
Person transport	**$486**	**$68**	**$555**	**1.6**	**0.2**	**0.8**
Passenger car	$385	$64	**$449**	**1.7**	**0.2**	**0.8**
Coach	$2.4	$0.6	**$3.0**	2.0	0.2	0.6
Other bus	$4.4	$1.2	**$5.6**	1.6	0.1	0.5
Motorcycle	$9.4	$1.4	**$11**	5.8	0.5	2.5
Long-distance rail	$0.18	$0.06	**$0.2**	0.9	0.1	0.2
Domestic aviation	$18	$0.4	**$19**	0.3	0.02	0.3
Urban bus	$51	-	**$51**	5.0	-	5.0
School bus	-	$0.8	**$0.8**	-	0.2	0.2
Urban rail	$1.0	-	**$1.0**	0.2	-	0.2
Urban ferry	$14	-	**$14**	15.7	-	15.7
Freight transport	**$559**	**$93**	**$652**	**4.5**	**0.3**	**1.7**
LCV	$327	$43	**$370**	**18.0**	**1.6**	**8.1**
MCV	$33	$9	**$42**	6.5	0.5	1.9
HCV	$137	$36	**$173**	**2.6**	**0.2**	**0.7**
Electric locomotive	$0	$0	**$0**	0.0	0.0	0.00
Diesel locomotive	$15	$4.2	**$19**	2.3	0.1	0.5
Coastal freighter	$47	$0.4	**$48**	1.2	0.0	0.9
Total ($M)	**$1,045**	**$161**	**$1,206**			

types and, when reflecting the relative efficiency of different services, also allow for the size of the transport task actually being undertaken (e.g., the number of person kms involved). This is reflected in the three RH column figures in each table, i.e., costs per person km (person travel) and costs per net tonne km (freight transport): these are the primary focus of discussion of the damage cost results in the following sections 11.2.5.2 (GHG emissions) and 11.2.5.3 (air quality emissions).

The total annual damage costs (total **$2,882Mpa**) are split $**1,676Mpa** relating to greenhouse gases, **$1,206Mpa** relating to air-quality emissions. Person transport accounts for 59% of the total GHG emission costs but 46% of the total air quality emission costs: this result reflects that the air quality costs are dependent on where people are actually exposed rather than where the emissions are released, eg, many airports in New Zealand are located in rural areas and contribute to GHGs equally but their air quality impact in these areas is relatively minor given their lower population densities.

11.2.5.2 GHG emissions results and comments

The GHG emissions total ($1,676M pa) comprises $984M (59%) from person transport modes and $691M (41%) from freight transport modes. We comment on the results for each of these sectors in turn in the following.

11.2.5.2.1 Person transport results

The total cost of $984M is dominated by car travel, which accounts for $841M (i.e., 85% of the total): this primarily reflects the dominance of cars in total traffic volumes. The second highest GHG emissions contributor is for domestic aviation ($103M, some 10.5% of the total). All other person transport modes together account for less than 5% of the total person transport emissions costs: the various bus modes account for the majority of this 5%.

The most relevant person transport metrics in tables 11.2.3 and 11.2.4 are the damage costs/person km (c/pkm). For the person transport modes, the damage cost per person km for cars (1.5c) is towards the high end of the unit cost range. Most types of bus services have somewhat lower emissions cost rates than cars (e.g., school buses at 1.0c/pkm and long-distance coach services at 0.7c/pkm); but notably, urban bus services have an average rate of 1.6c/pkm[84], i.e. almost the same as estimated for person car travel (ie 1.5c/pkm).

Urban rail and longer-distance rail services have the lowest damage cost rates, by a considerable margin, whereas urban ferry services have the highest rates (more than double those of other modes on a person km basis)[85].

11.2.5.2.2 Freight transport results

The total freight transport damage cost of $691M accounts for some 41% of the transport total (freight plus persons) emissions costs. The freight commercial vehicle cost component total of $595M accounts for 86% of the $691M figure. The next largest component is the $84M for coastal freight shipping which accounts for some 12% of the total freight sector damage costs. By comparison, rail freight environmental damage costs are very low, only $13M pa in total.

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[84] Note that this emission cost rate for urban bus services is based on bus operations in 2018/19: it is expected to reduce considerably with the proposed progressive electrification/decarbonisation of the urban bus fleet.

[85] With the progressive introduction of electric ferries to the NZ urban ferry fleet (primarily in Auckland and Wellington), the current relatively high GHG damage costs for ferries are expected to considerably reduce.

The most relevant freight metric (table 11.3.3) is that for total damage costs/net tonne km (NTK). Heavy commercial vehicles (trucks), which are the main competitor for rail and shipping modes, have an average damage cost of 1.0c/NTK. This is lower than the cost rates for coastal freighters (1.6c/NTK), but considerably higher than the cost rate for rail (which is dominated by diesel locomotives, with a rate of 0.4c/NTK).

11.2.5.3 Air quality results and comments

The air quality emissions damage costs total $1,206M pa, comprising $555M (46%) from person transport modes and $652M (54%) from freight transport modes. As in the GHG case, the most relevant metrics in tables 2.3, 2.4 are the damage costs/person km for person transport, and damage costs/net tonne km for freight transport. We comment on the results for each of these sectors in turn in the following.

11.2.5.3.1 Person transport results

The total cost of $555M is dominated by car travel, which accounts for $449M (81% of the total): this primarily reflects the dominance of cars in total traffic volumes. The second highest air quality emissions contributor is for urban bus services ($51M, some 9.2% of the total). All other person transport modes together account for the remaining 9.9% of the total person transport damage costs.

For the person transport modes, the damage cost per person km for cars (0.8c) is around the average of the unit cost range. Most types of bus services have somewhat lower emission cost rates than cars (e.g., school buses at 0.2c/pkm and long-distance coach services at 0.6c/pkm); but urban bus services have a much higher average rate of 5.0c/pkm, i.e., the highest of all modes apart from urban ferry. This high rate for urban bus services reflects that the great majority of their kilometres are operated within urban areas and that their average loadings (e.g., as measured by passenger km/vehicle km) are relatively modest, i.e., on average around 20% -25% of a full seated load.

Urban rail and longer-distance rail services have among the lowest damage cost rates, whereas urban ferry services have the highest rates by a considerable margin[86].

11.2.5.3.2 Freight transport results

The total freight transport damage cost related to air quality is $652Mpa, which is somewhat higher than the person transport total damage costs. The freight commercial vehicle cost component total of $585M accounts for 90% of this $652M figure. The next largest component is the $48M for coastal freight shipping, which accounts for some 7.4% of the total freight sector damage costs. By comparison, rail freight air quality damage costs are very low, only $19M in total.

The most relevant freight metric (table 11.2.4) is that for total damage costs/net tonne km (NTK). Heavy commercial vehicles (trucks), which are the main competitor for rail and shipping modes, have an average damage cost of 0.7c/NTK. This is less than the cost rates for coastal freighters (0.9c/NTK), but considerably higher than the cost rate by rail (which is dominated by diesel locomotives, with a rate of 0.5c/NTK).

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[86] With the progressive introduction of electric ferries to the NZ urban ferry fleet (primarily in Auckland and Wellington), the current relatively high air quality damage costs for ferries are expected to considerably reduce.

11.2.6 Priority aspects for further work

We have identified the following priority areas for potential future research.

(1) Incorporation of HAPINZ 3.0 damage costs and future air pollution studies

As mentioned, the damage costs used to value air emissions impacts in the DTCC work were taken from the Waka Kotahi ‘Monetised Benefits and Costs Manual’ and adjusted using preliminary HAPINZ 3.0 findings to indicate urban: rural cost ratios. This was best information publicly available at the time of preparation.

The HAPINZ 3.0 study has now been released (6 July 2022) and includes updated damage costs that are significantly higher than used in the DTCC work - principally because the true impact of NO2 emissions was not known. The major differences in terms of impact on the DTCC numbers are:

- HAPINZ 3.0 values NOx significantly higher (28x) than in DTCC e.g., $499,526 per t/urban versus $17,887.
- HAPINZ 3.0 values PM2.5 rather than PM10 which doesn't make much difference for transport exhaust emissions (but will likely impact the costing of road dust/brake & tyre wear for on-road vehicles in particular). Also, the HAPINZ urban number is 20% higher, $622,786 per t/urban versus $503,346.
- HAPINZ 3.0 found slightly lower rural to urban ratios, thereby reducing many of the rural damage costs by 50% (however, these are still dwarfed by the urban costs).

Adopting the HAPINZ 3.0 numbers would increase the air quality costs reported in this chapter more than 10-fold, as the social costs associated with transport-related air quality emissions for 2018/19 are now estimated at close to $11 billion rather than around $1.2 billion reported here.

As an added complication, the HAPINZ 3.0 (and MBCM) costs are based on the current VoSL which is being reviewed and will likely increase. If the VoSL does increase, then the damage costs for PM and NOx will be even higher and will warrant a further update.

We therefore recommend updating the DTCC documents with the revised HAPINZ 3.0 damage costs (and to be adjusted by the pending VoSL changes once the new VoSL is available). It is highly desirable that policy options are based on the latest and most consistent data across all agencies.

There would also be value in holding a workshop to identify ways in which HAPINZ 3.0 or its future iterations could be updated to better meet transport sector needs.

(2) Improved assessment of localised GHG and air quality costs

The methodology in the DTCC was able to distinguish damage costs as either urban or rural. Other jurisdictions, such as the UK Department of Food, Environment and Rural Affairs (DEFRA), publish damage costs which cover a much wider range of population density options.

The results of HAPINZ 3.0 may be able to be combined with currently available GIS-based tools – such as the Waka Kotahi Vehicle Emissions Mapping Tool – to improve the spatial/density resolution of the GHG and air quality costs resulting from domestic transport (at least for the road transport sector). This would enable improved assessment of smaller-scale transport policy/development changes or trends.

(3) Improved understanding of upstream and downstream emissions costs

As shown in the DTCC work to date, the impacts of upstream GHG energy emissions are comparable to those from the use of the energy in the transport mode. Currently we only have somewhat limited information for upstream GHG emissions, with no robust data available on upstream air quality emissions let alone any information on downstream emissions costs.

As a starting point, we would recommend undertaking a comprehensive literature review to establish the likely contribution of these additional upstream/downstream costs to the costs already identified. The next steps would then be to use this information to scope future research priorities.

(4) Improved understanding of costs/benefits of sustainable transport

The DTCC study does reflect the (likely) reduced contribution of sustainable transport modes to overall GHG and air quality costs for each mode. However, the benefits specifically associated with these modes versus conventional transport are not explicitly highlighted. With New Zealand increasing its momentum in addressing GHG emissions from transport (in particular), taking as holistic approach as possible to assessing emissions and associated costs from different transport modes is critical to ensuring responsible transport policy making and societal choices.

We recommend undertaking research to quantify the relative emissions contributions of sustainably-powered transport options for New Zealand (e.g., cars- battery electric, hybrid, v diesel, v petrol; electric buses, electric ferries etc) – again to inform robust decision making by policy makers and society at large. It is critical that this assessment encompasses upstream, in use and downstream emissions impacts, to the maximum extent possible.

11.3 Noise

11.3.1 Overview

Transport noise is widely considered as one of the most unpleasant and damaging impacts of transport systems and their usage, particularly in metropolitan/urban areas, and in the vicinity of major roads and railway lines. Long-term exposure to transport-generated noise can have detrimental effects on human health, amenity, and productivity. These effects have economic and social costs which are borne by the individual, the health system and the broader economy.

The primary purpose of the DTCC work on transport noise and its impacts was to estimate the total costs and the average costs of this noise exposure for different transport modes (road, rail, coastal shipping and domestic aviation) in the New Zealand context.

Our assessment estimated the average noise exposure costs, normalised by distance or movement, and disaggregated these where appropriate to assist with policy analysis. It also set out a methodology to estimate typical marginal noise costs: these reflect the noise impacts of marginal changes in traffic volumes on existing routes for typical categories of road and rail services.

11.3.2 Methodology

Methods were developed to estimate sound levels at residences from road, rail, domestic air and coastal shipping, based on currently available travel movement data.

Dose-response curves were established to estimate the population who are suffering from high annoyance, high sleep disturbance, or increased risk of ischemic heart disease as a result of transport noise. These impacts were expressed in terms of the number of 'Disability Adjusted Life Years' (DALYs), based on published 'disability weights' for each condition: these values were then monetised using the Value of Statistical Life (VoSL) estimated for New Zealand, which is a major component in the social costs of vehicle crashes[87].

Prior to this DTCC work, only limited studies in New Zealand had monetised effects from environmental noise, and no standardised method had been established. This study has largely adopted the methodology detailed in the European Environmental Agency (EEA) publication *Environmental noise in Europe — 2020.* A more comprehensive evaluation of monetisation methods for assessing transport noise is currently being undertaken by Waka Kotahi:[88] it would appear appropriate to review the methods and findings of the DTCC work reported here following completion of this Waka Kotahi study.

11.3.3 Results – Total and average costs

A summary of the total annual costs and average costs attributed to each of the main transport modes/modal categories is provided in table 11.3.1 (all costs are given in NZ$2018/19 prices, based on a 4% real discount rate).

Table 11.3.1: Total (annual) and average noise costs by mode (2018/19)

Source	Type	Total cost (2018/19)	Average passenger costs	Average freight costs
Road	Passenger (car etc)	$718 M	2.57 c/VKT 1.49 c/PKT	
	Freight (trucks)	$192 M		1.25 c/NTK
	Total	**$910 M**		
Rail	Passenger (urban)	$15 M	1.90 c/PKT	
	Freight	$58 M		1.50 c/NTK
	Total	**$72 M**		
Air	Passenger	**$37 M**	$79/landing or take-off	
Coastal shipping	Freight	**$4 M**		6.81 c/tonne
Total all modes		**$1,023 M**		

Total noise costs are estimated as annual figures, with a total cost over the four modes/categories of $1023 million. Some 90% ($910 million) of this total relates to road traffic, of which the great majority

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[87] We note that the Value of Statistical Life (VoSL) in the NZ context is currently under review through consultant studies being undertaken for Waka Kotahi.

[88] Waka Kotahi *ART 19-01 - Social cost (health) of land transport noise exposure in New Zealand.*

(79%) relates to person travel (mainly by car), the remainder to freight (truck movements). The total noise costs for rail traffic are much lower, at $72 million, of which the majority relates to rail freight movements. The other two modes (domestic aviation, coastal shipping) account for the final 4% of total noise costs, with domestic passenger aviation accounting for $37 million and coastal shipping for a further $4 million[89].

Average costs were derived from the total annual cost figures by dividing by the most appropriate measure of the transport task (details given in table 11.3.1). For road and rail person travel, the measure applied is person kilometres (PKT); for road and rail freight movements, the most appropriate measure is net tonne kilometres (NTK). For air passenger travel, the measure used is $ per landing or take-off event (given that the noise nuisance relates primarily to these events). Similarly, for coastal shipping, the measure used is cents per tonne of freight transported.

11.3.4 Results – Marginal costs

A marginal costing methodology was developed and applied to estimate typical marginal noise costs for small (marginal) changes in traffic volumes on the existing transport networks[90]. The general finding is that marginal cost rates (per incremental VKT etc) are typically 20% - 30% of average cost rates for the existing traffic.

11.3.5 Priority aspects for further work

The methods adopted in this study have been designed to allow simple updates for rail and airport movement numbers, without requiring extensive noise mapping. Road noise exposure has been based on detailed predictions made by/on behalf of Waka Kotahi, which are expected to be updated periodically.

11.4 Biodiversity and Biosecurity

11.4.1 Overview

This section assessed the ‘costs’ of using our environment to deal with ground-based emissions from the domestic transport system, and the impacts on biodiversity from the provision and operation of transport infrastructure and services.

Importantly this assessment only considers the annualised costs (total and average) associated with the operation of **existing** transport infrastructure and estimates the cost of upgrading existing infrastructure to remediate effects. It does not consider the costs of consenting or construction of new infrastructure or the associated effects on terrestrial vegetation, habitats, and fauna of such works.

Our work was concerned with the domestic transport system and primarily road, rail and coastal shipping operations. (Initial consideration was also given to domestic air travel, but this did not progress further as it was considered unlikely to have significant effects.)

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[89] The cost estimates for air passengers and coastal shipping freight are considered the least accurate of the estimates for the four modes. In both cases, the figures largely relate to noise at the start and end of the journeys (i.e., at/near the airport or seaport concerned).

[90] The marginal costing methodology developed is set out in DTCC WP D5 (section 5.3), with a primary emphasis on methods for the road network.

11.4.2 Consideration of alternative methods

Our investigations initially explored the range of methods that have been applied nationally and internationally to assess ecosystem value and costs (harm) to biodiversity of these transport modes. We found that all previous approaches were proxies for harm with greater or lesser relevance and limitations. None put a value on the ecosystem being affected, addressed the actual harm being done to the environment, or considered the cost of avoiding or minimising that harm.

We therefore sought to better understand the degree of environmental harm of each transport mode by considering “Contingent Valuation” (willingness to pay) methods. Using this model, the term “cost” relates to the estimated annual dollar value of the “loss of ecosystem function” due to environmental degradation. In addition, we considered a “Cost to Treat” scenario which sought to put an annual dollar value on minimising or limiting environmental harm below thresholds of concern. For this approach we assessed recent treatment methods, with the annualised installation and maintenance cost assuming a 50yr design life.

11.4.3 Results summary and commentary

We concluded that roading has the greatest potential impact on New Zealand’s ecology given its scale of infrastructure, number of vehicle movements, and tonnes of freight moved. The key biodiversity/ecological costs of roading are related to stormwater and contaminant discharge to streams and the near-shore coastal environment.

We concluded that rail has a much smaller scale of impact due to its less extensive, narrow, fixed and contained corridors, with much fewer movements of trains, both passenger and freight, and a much smaller volume of freight carried. Like roading, the key ecological costs of rail are related to the discharge of contaminants from the rail corridor to streams and the coastal environment.

Coastal shipping has the most complex and diverse range of ecological effects, extending across onshore, estuary, harbour, coastal and marine environments. It also impacts on specific marine fauna. Several methods were used to value affected environments and cost each component of harm. We note that our cost assessments for coastal shipping combined all forms of ecological damage caused by the relevant port and shipping activities in total; but we then took only a proportion (13% on average) of these total impacts, based on the tonnage of coastal shipping through the relevant port relative to the total port throughput.

In terms of biosecurity, roading and domestic shipping are considered to be the main mechanisms for the dispersal of Alien Invasive Species (AIS) that arrive in New Zealand: rail (and air) are relatively minor contributors. However, after considering all available information we concluded that it was not possible to apportion economic biosecurity costs to any one or a combination of the four transport modes. As a result, no quantified analysis of biosecurity impacts was carried out.

Results are summarised in Table 11.4.. In this table the road and rail transport modes include contingent valuation without treatment (A) as a stand-alone cost. This equates to the perceived annual value of loss of ecosystem services. In addition, contingent valuation with treatment (B1) is provided, allowing also for the additional cost to treat (B2): the two values are additive. The total annual costs caused by each mode were first estimated, with their allocation between road and rail made on the basis of relative damage factors.

Table 11.4.1: Assessment of biodiversity total and average costs by transport mode (treatment costs in NZ $million p.a.)[91]*.*

	Total costs	**Average costs**	
Road Transport	**Costs p.a. ($m)**	**c/person km (person travel)**	**c/net tonne km (Freight travel)**
A. Contingent Valuation (Without treatment)	131.15	0.142	0.135
B1. Contingent Valuation (With treatment @ 70%)	21.48	0.023	0.022
B2. Cost to Treat (Annualised ~ 50yr design life	105.05	0.114	0.108
Rail Transport	**Costs p.a. ($m)**	**c/person km**	**c/net tonne km**
A. Contingent Valuation (Without treatment)	0.47	0.030	0.007
B1. Contingent Valuation (With treatment @ 70%)	0.06	0.007	0.000
B2. Cost to Treat (Annualised ~ 50yr design life	0.36	0.013	0.004
Coastal Shipping	**Costs p.a. ($m)**	**Cost/NTK(c)**	**Cost/tonne ($)**
Total combined cost	34.43	0.744	6.620

11.4.4 Limitations, future updates, and potential additional areas of work

This study has identified a significant gap in knowledge and understanding of the scale, distribution, and severity of effects on biological systems from the maintenance and operation of each transport mode considered. We concluded with a range of suggestions for improving knowledge and understanding of biodiversity and biosecurity values, the effects (costs) on them of transport activities, and allocation of those costs between transport modes.

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[91] Average costs in this table are expressed per (i) person kilometre of travel for person movements and (ii) net freight tonne kilometres for freight haulage. Estimates of annual person km and freight net tonne km are based on DTCC analyses by IWA for year 2018/19.

Appendix A: Glossary [Work in progress]

Term	Definition
AC	Auckland Council
AC	Average cost
ACC	Accident Compensation Corporation
AKL	Auckland
AT	Auckland Transport
BC	Black carbon
B/bn	Billion
CAF	Construcciones y Auxiliar de Ferrocarriles (Spanish supplier of Auckland's commuter trains)
CAM	Cost allocation model
CBD	Central business district
CH_4	Methane
CHC	Christchurch
CO_2	Carbon dioxide
CO_{2e}	Carbon dioxide equivalent
CRL	City Rail Loop (Auckland)
DALY	Disability-adjusted life year
Depn	Depreciation
DHC	Depreciated historic cost
DRC	Depreciated replacement cost
DTCC	Domestic Transport Costs and Charges (this study)
DTIMS	Deighton Infrastructure Management System
EMU	Electric multiple unit
ESA	Equivalent standard axle
ETS	Emissions trading scheme
exc	Excluding
FAC	Fully allocated costs
FED	Fuel excise duty
FIGS	Freight Information Gathering System
GHG	Greenhouse gases
GPS	Global positioning system
GST	Goods and services tax
gtkm	Gross Tonne Kilometre(s)
GWRC	Greater Wellington Regional Council
HAPINZ	Health and Pollution in NZ (study)
HCV	Heavy commercial vehicle
HCV2	50 Max HCV
HSWA	Health and Safety at Work Act 2015
HTS	Household travel survey
IWA	Ian Wallis Associates

KR	KiwiRail
KR	KiwiRail
LAPT	Local authority petroleum tax
LCV	Light commercial vehicle
LGAs	Local government authorities
LRMC	Long run marginal cost
LRs	Local roads
M	million
MC	Marginal cost
MCV	Medium commercial vehicle
MoT	Ministry of Transport
Mpa	Millions per annum
Mtce	Maintenance
N'wk	Network
NFDS	National Freight Demand Study
NI	North Island
NIMT	North Island Main Trunk
NLTF	National Land Transport Fund
NLTP	National Land Transport Programme
ntkm	Net tonne kilometre(s)
NZRC	New Zealand Railways Corporation
NZRC	NZ Railways Corporation
NZTA	Waka Kotahi New Zealand Transport Agency
NZTA	New Zealand Transport Agency (Waka Kotahi)
O&M	Operations and Maintenance
ODRC	Optimised depreciated replacement cost
Opns	Operations
Pax	Passenger
PAYGO	Pay-as-you-go
PCU	Passenger car units
PEFM	Petroleum or engine fuel monitoring
pkm	Passenger kilometre(s)
PKT	Person kilometres travelled
PPP	Public Private Partnership(s)
PT	Public transport
PTOM	Public Transport Operating Model
QALY	Quality-adjusted life year
RA	Railways Act 2005
RC(s)	Regional Council(s)
RFT	Regional fuel tax
RMA	Resource Management Act 1991
RNIP	Rail network investment programme
RoPax	Roll-on roll-off passenger ferry

RoRo	Roll-on roll-off ferry
RUC	Road user charges
SCI	Statement of Corporate Intent
SH(s)	State Highway(s)
SI	South Island
SMC	Social marginal cost
SOE	State-Owned Enterprise
SOE	State owned enterprise
SRMC	Short run marginal cost
STCC	Surface Transport Costs and Charges (study)
TAIC	Transport Accident Investigation Commission
TEU	Twenty foot equivalent unit (shipping container)
TLA	Territorial local authority
TOF	Transport Outcomes Framework
TTW	Tank to wheel
TUC	Track User Charge
UPT	Urban public transport
Veh	Vehicle
VKT	Vehicle kilometres travelled
VoSL	Value of statistical life
WACC	Weighted average cost of capital
Waka Kotahi	Waka Kotahi New Zealand Transport Agency
WK	Waka Kotahi (NZ Transport Agency, NZTA)
WLG	Wellington
WP	Working paper
WTP	Willingness-to-pay
WTT	Well to tank
WTW	Well to wheel

Appendix B: DTCC working papers

Ref[92]	Working paper title	Consultant company	Principal contributors
	GENERIC TOPICS		
B5	Weighted average cost of capital (WACC)	TDB Advisory	Phil Barry
	MODAL TOPICS		
C1.1	Road infrastructure – marginal costs	David Lupton & Associates	David Lupton
C1.2	Road infrastructure – total & average costs	David Lupton & Associates	David Lupton
C2	Valuation of the road network	Richard Paling Consulting	Richard Paling
C3	Road network and public transport expenditure & funding overview	Richard Paling Consulting	Richard Paling
C4	Road vehicle ownership & use charges	Richard Paling Consulting	Richard Paling
C5	Motor vehicle operating costs	Richard Paling Consulting	Richard Paling
C6	Long-distance coaches	David Lupton & Associates	David Lupton/ Adam Lawrence
C7	Car parking	Veitch Lister Consulting	Stuart Donovan
C8	Walking & cycling	Veitch Lister Consulting	Stuart Donovan
C9	Ride-hailing & taxis	Veitch Lister Consulting	Stuart Donovan
C10	Micro-mobility	Veitch Lister Consulting	Stuart Donovan
C11.2	Rail regulation	King & Small Consultancy	Murray King
C11.3	Rail investment	King & Small Consultancy	Murray King
C11.4	Rail funding	King & Small Consultancy	Murray King
C11.5	Rail operating costs by market segment	King & Small Consultancy	Murray King
C11.6	Rail safety	King & Small Consultancy	Murray King
C12	Urban public transport	Ian Wallis Associates	Ian Wallis/ Adam Lawrence
C14	Coastal shipping (freight)	Rockpoint Corporate Finance	Chris Stone
C15	Cook Strait ferry services	Rockpoint Corporate Finance	Chris Stone/ Murray King
	IMPACT (EXTERNALITY) TOPICS		
D1	Costs of road transport crashes	ViaStrada	Glen Koorey
D2	Congestion costs	David Lupton & Associates	David Lupton
D3	Health impacts of active transport	University of Otago (WGN)	Anja Misdrak & Ed Randal
D4	Air quality and greenhouse gas emissions	Emission Impossible	Gerda Kuschel
D5	Noise	Altissimo Consulting	Stephen Chiles & Michael Smith
D6	Biodiversity & biosecurity	Boffa Miskell	Stephen Fuller

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[92] Reference numbers refer to the DTCC Scoping Report, May 2020