Domestic Transport Costs and Charges Study

Working Paper C12
Urban Public Transport

Prepared for Te Manatū Waka Ministry of Transport (NZ)
Ian Wallis Associates Ltd
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Contents

Appendices

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The Research, Economics and Evaluation team operates within the System Performance and Governance Group of Te Manatū Waka Ministry of Transport. The team supports the Ministry's policy teams by providing the evidence base at each stage of the policy development.

The team is responsible for:

- Providing sector direction on the establishment and use of the Transport Evidence Base (see below) – including the collection, use, and sharing of data, research and analytics across the transport sector and fostering the development of sector research capabilities and ideas.
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The Transport Evidence Base

The Transport Evidence Base Strategy creates an environment to ensure data, information, research and evaluation play a key role in shaping the policy landscape. Good, evidence-based decisions also enhance the delivery of services provided by both the public and private sectors to support the delivery of transport outcomes and improve wellbeing and liveability in New Zealand.

The Domestic Transport Costs and Charges study aims to fill some of the research gaps identified in the 2016 Transport Domain Plan (Recommendation R6.2), which forms part of the Transport Evidence Base.

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For more information

For more information about this project and associated report, please contact: info@transport.govt.nz.

Executive summary

S1. OVERVIEW

This working paper sets out the DTCC analyses relating to Urban Public Transport (UPT) passenger services in New Zealand. The three principal UPT modes in New Zealand are bus (all regions), urban rail (Auckland or AKL and Wellington or 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:

- ***Chapter 2***: ***Overview of the national picture***. This focuses on the supply and demand of UPT services during 2018/19 and their costs and performance measures, on a national aggregate basis. In addition, some regional information is provided on the three main UPT modes. To better understand UPT investment and operation costs, 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 set out in Appendix D, (with an overview of findings included in this section.).
- ***Chapter 3***: ***Case study appraisal of Wellington urban rail services in 2018/19***. This analyses the total costs, average costs and user charges (fare revenues) for WLG 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.
- ***Chapter 4***: ***Case study appraisal of Wellington bus services in 2018/19***. This analyses WLG bus service costs, patronage and fare revenues to assess their 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 only - analyses by individual corridor or route have not been carried out.

While our study appraisals for urban rail and bus services have both related to the Wellington operations, the underlying cost and performance ratios for the rail services in Auckland and the urban bus services in most other regions are broadly similar to those for the Wellington services (e.g. in terms of the vehicle characteristics, staffing arrangements and pay rates] and consequently in terms of unit cost levels.

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 (see Appendix 3).

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 additional cost to the roading network, congestion and environmental impacts, are the subject of other DTCC working papers.

S2. NATIONAL PICTURE

S2.1. 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 and Wellington). 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 Waka Kotahi). The total gross costs of some $1,300 million p.a. (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).[1]

S2.2. Local public transport service statistics and performance (2018/19)

Table S2.1 provides a summary of 2018/19 NZ UPT 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)[2].
- 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 ($1,306 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

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

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

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). [3]

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

Ref	Indicator (1)	Units	Bus	Train	Ferry (2)	All	Total/Ave
Patronage and fare revenue							
D1	Passenger boardings	mill	126.0	35.8	7.9	-	**169.7**
			74%	21%	5%	-	100%
D2	Passenger km	mill kms	890.3	606.9	90.8	-	**1,588.1**
			56%	38%	6%	-	100%
D3	Fare revenues (3)	$mill	212.4	106.0	41.3	-	**359.7**
			59%	29%	11%	-	100%
D4	Avg distance/boarding	km	7.07	16.94	11.55	-	**9.36**
D5	Fare rev/pass boarding	$	1.69	2.96	5.25	-	**2.12**
D6	Fare rev/pass km	$	0.239	0.175	0.455	-	**0.227**
Operations and costs							
S1	Service kms (4)	mill	115.82	7.99	1.65	-	**125.46**
			92%	6%	1%	-	100%
S2	Gross costs (5)	$mill	771.3	513.3	72.0	130.8	**1,487.4**
			52%	35%	5%	9%	100%
S3	Gross costs/service kms	$	6.66	64.26	43.58	-	**11.86**
Supply and demand indicators							
R1	Pass km/service km (avg load)	#	7.69	75.99	54.99	-	**12.66**
R2	Gr costs - rev (net subsidy)	$mil	558.9	407.2	30.7	130.8	**1,127.7**
			50%	36%	3%	12%	100%
R3	Fare rev/cost ratio (cost recov) %	%	27.5%	20.7%	57.4%	-	24.2%
R4	Gross costs/pass boarding	$	6.12	14.32	9.16	-	**8.77**
R5	Gross cost/pass km $	$	0.866	0.846	0.793	-	**0.937**
R6	Net subsidy/pass boarding	$	4.44	11.36	3.90	-	**6.65**
R7	Net subsidy/pass km	$	0.628	0.671	0.338	-	**0.710**

Notes:

(1) All financial figures exclude GST

(2) Ferry statistics include a small component for the Wellington cable car service

(3) 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 substitute)

(4) Service kms for trains based on train distances (not unit or carriage distances)

(5) Gross cost by mode excludes a small component of non-allocated costs that apply to all modes

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

[3] 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).

centres and their 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 (i.e. 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.

S2.3. Medium term financial outlook (up to 2023/24)

This area of (additional) work involved an analysis of UPT expenditure and revenue forecasts (from the NLTP and other sources) for the six-year period 2018/19 – 2023/24. The following $ figures in this section have been 'deflated' to 2018/19$ terms, so as to be directly comparable with the figures in the other sections of this paper (and throughout the DTCC study), which are all expressed in $2018/19.

Data were provided by WK for annual expenditure and fare revenue forecasts by region, mode, project type and work category for the two NLTP periods (ie 2018/19-2020/21, 2020/21-2022/23). This source was augmented by data for other proposed UPT expenditures for a number of major capital projects which are being funded through sources other than the NLTP.

The following summarises the aggregate expenditure levels and trends over the six-year period, expressed relative to the 2018/19 levels, by mode (rail, bus, ferry) at an aggregated national level[4]:

- ***Operating costs.*** Over the six-year period, total opex increases from its 2018/19 level at a gradual rate, increasing by around 30% (real terms) over the period.
- ***Capital costs***. The forecast level of capital expenditure increases steeply over the period compared to the 2018/19 level. The increase is from about $440 million in 2018/19 to $1050 million in 2019/20 and to approximately $2,000 million in 2021/22 and for the following two years.
- ***Cost recovery.*** As a proportion of total opex, capex will increase from around 40% in 2018/19 to about 150% from 2020/21 onwards. The great majority of the capex relates to urban rail, principally in Auckland: the Auckland City Rail Link (CRL) is a major contributor to this sharp increase in capex[5]. The result of this rapid increase in costs, together with forecasts of only small changes in fare revenues, is that the overall national UPT cost recovery on opex alone is forecast to decline from 34% in 2018/19 to 26% from 2019/20 onwards; while the cost recovery on total costs (Ie including capex) would decline from 24% in 2018/19 to 10%-11% from 2020/21 onwards.

[4] Through this work, IWA compiled a detailed (Excel-based) database of forecast annual expenditures and revenues for the six-year period by region, mode, work category, project type/description, etc.

[5] All our analyses were completed in late 2022, so they pre-date (and exclude) the cost increase for CRL of around $1000 million which was announced in March 2023.

S3. URBAN RAIL SERVICES -- WELLINGTON CASE STUDY

S3.1. 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).[6]
- 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.

S3.2. Total rail operating costs

Total operating costs for the Wellington rail system (2018/19) were some $148 million, disaggregated as shown in Table S3.1.[7]

[6] 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) and is covered in WP C11.5

[7] 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 S3.1: Summary of Wellington Rail Operating Costs and Capital costs & 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 cost and capital charges:		
Depreciation - rolling stock	13.40	Depreciation charges used for accounting purposes (taken as a proxy for economic depreciation)
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**	

S3.3. Rail system performance statistics and allocated cost analyses

Table S3.2 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.

Table S3.2: 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 SupergoldCard 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).[8] 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 85% 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 (i.e. Waikanae and Upper Hutt) are around $10 per boarding, somewhat lower in the peak periods, higher in the off-peak periods.

S3.4. 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.
- ***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 p.a. (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.

In practice, there is little scope for increasing the current peak period (peak direction) passenger throughput on the main lines without substantial capital expenditure. Recent/current business case studies have investigated a range of options for expending peak period capacity, including: (I) additional rolling stock, so as to operate all peak services with 8-car trains; (ii) signalling system upgrading, so as to allow for higher service frequencies; and (iii) duplicating the current single line sections of the main routes. Some work has recently been undertaken on these single line sections; but decisions have yet to be taken on the priorities for further capacity expansions beyond this stage.

[8] 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.

S4. URBAN BUS SERVICES -- WELLINGTON CASE STUDY

S4.1. 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 to 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[9]. These higher rates have been used in Chapter 2, which is based directly on the annual financial statistics for each region[10].

The bus cost model[11] developed for the Wellington bus case study (detailed in section 4.2) is as follows:

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

Note that: (i) the model relates to 'standard'-size (c 40 seat) diesel buses; (ii) the 'peak bus'[12] 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 p.a. 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 of bus operator costs, although there is little difference in this case: the model includes road user charges, licence fees etc on a comparable basis as for trucks of similar weight and axle configuration. However, it should also be noted that the bus services themselves are heavily subsidised, such that user revenues cover only around one-third of total bus operating costs (the major portion of the costs is funded through central and regional government subsidies).

[9] 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.

[10] This working paper includes all costs attributable to the mode where it operates on a 'stand-alone' basis, and an allocation of joint costs in the case of assets also used by other operators (e.g. the urban rail network). The cost allocations in such cases are determined through agreements between GW and KiwiRail, based on well-established good practices in such cases. Public infrastructure costs are assessed based on economic return on capital approach.

[11] The bus cost model covers all the 'operating' costs involved in the provision of bus services, but generally excludes the Regional Councils' overheads such as contract management, etc.

[12] The term "peak bus" refers to the number of buses required to cover the peak period operation.

S4.2. 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)[13]:

- Service km, service hr, maximum bus requirements
- Passenger boardings, passenger kilometres
- Fare revenues[14], Supergold revenues.[15]

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[16].

Table S4.1 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 S4.1: Allocated Costs and Charges Summary (2018/19), Wellington bus[17]

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

[13] 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)

[14] The current Wellington PT fare system is based on a series of (broadly) concentric zones radiating from Wellington CBD. The fares for any trip are based on the trip boarding and alighting zones; but with zonal structure being such that the fares per kilometre for longer trips are significantly less than those for shorter trips.

[15] 'Supergold' is the standard national scheme involving reduced fares for senior citizens aged 65 and over, 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).

[16] 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 Section 4.3).

[17] Most of the data in Table S4.1 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.

S4.3. 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)[18].

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.

S4.4. 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 financial costs (i.e. marginal costs - marginal revenues) being close to zero.[19]

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[18] 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.

[19] 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 marginal passenger. [20]

These benefits to existing users associated with additional passengers are a simple function of: (i) initial headway[21], (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.[22]

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[20] 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.

[21] Headway (usually in minutes) refers to the average interval between trains or buses on a regular service.

[22] 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.

Chpater 1 Introduction

1.1 Study Scope and Overview

The Domestic Transport Costs and Charges (DTCC) study aims to identify all the costs associated with the domestic transport system and its impacts on the wider New Zealand economy, including costs (financial and non-financial) and charges borne by transport users.

The Study is an important input to achieving a quality transport system for New Zealand that improves wellbeing and liveability. Its outputs will improve our understanding of the economic, environmental and social costs associated with different transport modes - including road, rail, public transport and coastal shipping - and the extent to which those costs are currently offset by charges paid by transport users.

The DTCC is intended to support the wider policy framework of Te Manatū Waka, in particular the Transport Outcomes Framework (TOF). The TOF seeks to make clear what government wants to achieve through the transport system under five outcome areas:

- Inclusive access,
- Economic prosperity,
- Healthy and safe people,
- Environmental sustainability, and
- Resilience and security.

Underpinning the outcomes in these areas is the guiding principle of mode neutrality. In general, outputs of the DTCC study will contribute to the TOF by providing consistent methods for (a) estimating and reporting economic costs and financial charges; and (b) understanding how these costs and charges vary across dimensions that are relevant to policy, such as location, mode, and trip type.

Robust information on transport costs and charges is critical to establishing a sound transport policy framework. The Study itself does not address future transport policy options; but the study outputs will help inform important policy development in areas such as charging and revenue management, internalising externalities, and travel demand management.

The Study was undertaken for Te Manatū Waka by a consultant consortium headed by Ian Wallis Associates Ltd. The Study has been divided into a number of topic areas, some of which relate to different transport modes (including road, rail, urban public transport and coastal shipping), and others to transport-related impacts or externalities (including accidents, congestion, public health, emissions, noise, biodiversity and biosecurity).

Working papers (25) have been prepared covering each of the topic areas. Their titles, topic areas and specialist authors are listed in Appendix 5.

1.2 Costing Practices

The focus of DTCC is on NZ transport operations, economic costs, financial costs and charges for the year ending 30 June 2019 (FY 2018/19). Consistent with this focus, all economic and financial cost figures are given in NZ$2018/19 (average for the 12-month period) unless otherwise specified.

All financial costs include any taxes and charges (but exclude GST); while economic costs exclude all taxes and charges.

The DTCC economic and financial analyses comprise essentially single-year assessments of transport sector costs and charges for FY 2018/19. Capital charges have been included in these assessments, with annualised costs based on typical market depreciation rates plus an annualised charge (derived as 4% p.a., in real terms, of the optimised replacement costs of the assets involved).

1.3 Paper scope and structure

This working paper 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 passenger (AKL and WLG) and urban ferry (principally AKL, but also plays a small role in several other regions).

This work has been undertaken by Ian Wallis Associates (IWA) in close collaboration with two main parties, Waka Kotahi and Greater Wellington Regional Council (GWRC): the work would not have been possible without their cooperation, supply of extensive data and review of draft material.

The work has focused on three main topic areas:

- ***Chapter 2***. Overview of the national picture – analyses 2018/19 UPT supply, demand and cost statistics and performance measures, initially on a national aggregate basis and then split between the three main modes involved and by region. Supplementary work under this topic, but covering the six-year period 2018/19 – 2023/24, was commissioned subsequent to completion of the original work (this is reported in appendix D).
- ***Chapter 3***. Detailed case study appraisal of urban rail services in the Wellington region. This case study analyses the total costs, average costs and user charges (fare revenues) for Wellington's current urban rail system, disaggregated by time period (peak/off-peak) and rail line. Less detailed analyses address the marginal (financial) costs associated with supply-induced changes (i.e. changes in service levels) and with demand-induced changes (i.e. the likely service response to exogenous changes in demand).
- ***Chapter 4.*** Detailed case study appraisal of urban bus services in the Wellington region. This case study comprises:
    - development of an urban bus service costing model reflecting bus cost structures in the main NZ urban centres;
    - analysis of 2018/19 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;
    - assessment of marginal (financial) operating costs, to estimate the incremental costs associated with increases or decreases in levels of service by time period; and
    - assessment of marginal 'economic' costs associated with exogenous changes in demand, covering both marginal financial costs resulting from service changes in response to the demand changes and also economic costs and benefits ('externalities') to existing bus users resulting from these changes.

In addition to the above, five appendices are provided:

- ***Appendix 1***. Detailed information on the 'user economies of scale' (Mohring) effect for public transport (supplementary to chapter 4).
- ***Appendix 2.*** Overview and statistical summary of the NZ 'Total Mobility' scheme, which is targeted to those people who have difficulty in using 'conventional' public transport services (supplementary to chapter 2).

- ***Appendix 3.*** Summary of performance statistics for the Ministry of Education (MoE) school bus services (focused on school transport in rural areas), including some performance comparisons with the UPT services. [Note: The MoE services were not included in the DTCC study scope, as they are funded and managed outside the transport sector: this appendix is therefore included for interest only.]
- ***Appendix 4.*** Additional analyses of the national/regional picture covering the 6 years 2018/19 – 2023/24, so as to provide a longer-term perspective on the trends in the UPT sector, thereby supplementing the chapter 2 material.
- ***Appendix 5.*** Listing of DTCC working papers, including their authors and author affiliations.

With the exception of the MoE services, all the other modes/service types covered in this paper are managed and funded by the regional councils (with funding contributions from central government, administered by Waka Kotahi). We note that the paper does **not** cover longer-distance passenger services provided by coach and train (and operated on a commercial basis); and it also does not cover demand-responsive services (provided by taxi and ride-hail operators, also on a commercial basis). These other services are addressed in separate DTCC working papers.

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 addressed in other DTCC working papers.

Chpater 2 NZ Urban Public Transport Statistics and Performance

2.1 National and modal overview -- costs, revenues and funding

2.1.1 Key features of our analyses

The following three important points should be kept in mind in interpreting the findings of this paper, and in particular those in this chapter:

- ***Interpretation of costs.*** All costs given are essentially financial costs (rather than economic costs), except where specifically noted. The great majority of costs are of a recurrent nature, although a small proportion (in the order of 10% of total costs considered) are of a capital nature: these relate to (i) replacement (including betterment in some cases) of life-expired assets; and (ii) in some cases, new infrastructure etc associated with expansion of services. Note that capital costs associated with public transport vehicles are in most cases 'operationalised' for accounting purposes: bus and ferry fleets are owned by their operators, who recover their costs over the life of the assets from regional council contracts and/or other services operated. Rail fleet costs are similarly amortised for operator accounting purposes and for the purposes of our analyses.
- ***Cost recovery performance.*** Cost recovery ratios are used in this paper as a measure of the financial performance of PT services: they are measured as the ratio between fare revenues collected and total financial costs (as defined above). We note that the ratios in this paper are lower than those frequently quoted by Waka Kotahi as the "farebox recovery ratios" of the public transport system. The main reason for the difference is that the Waka Kotahi ratios include in their cost line only what they describe as operating costs, which are principally (but not solely) the costs of their contracts with operators. By contrast, the cost line in our cost recovery ratio estimates also includes other costs (not included in the operator contracts), such as infrastructure maintenance and management, passenger information and marketing services, and general management overheads.
- ***Interpretation of revenues.*** The main contributor to the difference in cost recovery ratios used in this paper and those used by Waka Kotahi is on the cost side, as described above. In addition, there is a small contributor on the revenue side, relating to the treatment of Supergold payments from government to regional councils in compensation for their reduced fare revenue resulting from the Supergold scheme. The Waka Kotahi "farebox recovery ratio" treats these government compensation payments as part of its revenue line; whereas the cost recovery ratio figures given in this paper treat them as part of general subsidies rather than part of farebox revenues.

2.1.2 National costs and revenues overview

Figure 2.1.1 provides an overview of cost categories and revenue sources relating to NZ UPT services in 2018/19. This is supported by Table 2.1.1 which sets out cost (expenditure) amounts and revenue (funding) sources in $ terms.

Key findings are as follows:

- ***Costs*[23]*:***

[23] This working paper includes all costs attributable to the mode where it operates on a 'stand-alone' basis, and an allocation of joint costs in the case of assets also used by other operators (e.g. the urban rail network). The cost allocations in such cases are determined through agreements between GW and KiwiRail, based on well-established good practices in such cases. Public infrastructure costs are assessed based on economic return on capital approach.

  - Total costs for the year were $1,487 million, of which $1,045 million was for recurrent (opex) costs and the remaining $443 million was for infrastructure development and related investments (capex items).
  - The major part ($945 million) of the recurrent cost amount was spent on 'service operations', representing the costs of operating and maintenance contracts with service providers.
  - Lesser amounts related to information, marketing and ticketing costs ($60 million) incurred by the Regional Councils (RCs) and to the operation and maintenance of infrastructure ($39 million).
- ***Revenues and funding:***
  - total revenues from users were $360 million, almost all from passenger fares. This equated to 34.5% of total operating costs or 24.2% of all (opex plus capex) costs.
  - A further $31 million was paid by Government to the RCs as a 'fare substitute' to recompense for free travel provided to Supergold card holders. If this amount is included, the total user revenues would increase to 26.3% of the total costs.
  - The remaining 75.8% of the total costs was funded between regional councils ($400 million, through regional rates), Waka Kotahi ($531 million, through the NLTF) and direct Crown funding $166 million).
  - Until recently, Waka Kotahi policy was that user revenues (including Supergold payments) should cover 50% of service operations costs, which would equate to $473 million: actual user revenues ($360m) fell well short of meeting this target.

Figure 2.1.1 Urban public transport costs and revenues structure 2018/19

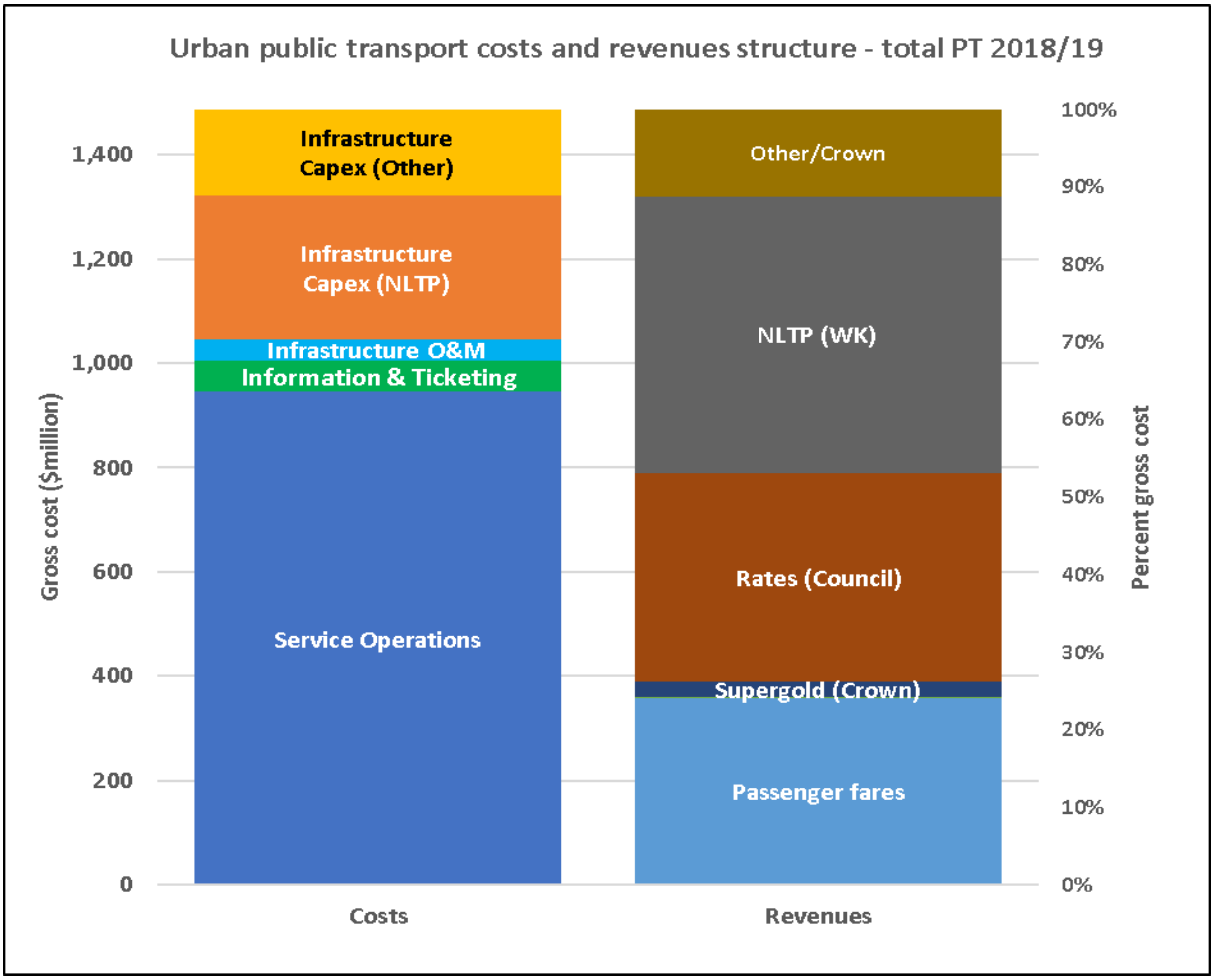


Table 2.1.1: Urban public transport costs and revenues summary 2018/19

Category	Type	Costs	Revenues
Opex	Service Operations	945	
	Information & Ticketing	60	
	Infrastructure O&M	39	
Capex	Infrastructure Capex (NLTP)	277	
	Infrastructure Capex (Other)	166	
User	Passenger fares		358
	Third party		2
Subsidy	Supergold (Crown)		31
	Rates (Council)		400
	NLTP (Waka Kotahi)		531
	Other/Crown		166
Total Revenue		**1,487**	**1,487**

2.1.3 Costs and revenues by mode and regional category

Figure 2.1.2 (gross costs) and Figure 2.1.3 (revenue sources) provide a further breakdown of the Figure 2.1.1/Table 2.1.1 information by: (i) mode (bus/train/ferry); and (ii) bus, split between large, medium and 'other' regions (categorised in terms of their PT market size)[24]. In both these figures, the scale for the x-axis is proportional to the gross costs of each of the modes and regions, and the y-axis shows the proportions of total gross costs (and revenues) associated with the different sources.

On the **cost** side (Figure 2.1.2), the proportion of the total costs relating to service operations is higher for the bus and ferry modes (75% – 80%) than for the train mode (c 60%, which reflects the higher proportion of capital costs for the latter). Among the bus services, there is some tendency for cost recovery to be higher in the larger regions than in the medium/smaller regions.

On the **revenue** side (Figure 2.1.3), the proportion of total revenues (which equate to total costs) covered by passenger fares is the lowest for the train services (around 20%), higher for the bus services (around 27%) and highest for the ferry services (around 55%)[25]. There is little difference between the bus services in the large, medium and other regions in terms of their cost recovery proportions.

[24] For this purpose, the 'large' regions are AKL, WLG, CAN; the 'medium' regions are OTA, WAI, BOP, HOR; with the remaining six regions being classified as 'other'.

[25] the ferry service figures include estimates for Auckland's Devonport and Waiheke services, which are categorised as 'exempt' services under the PTOM legislation (and therefore do not receive any subsidies).

Figure 2.1.2 Gross costs by mode 2018/19

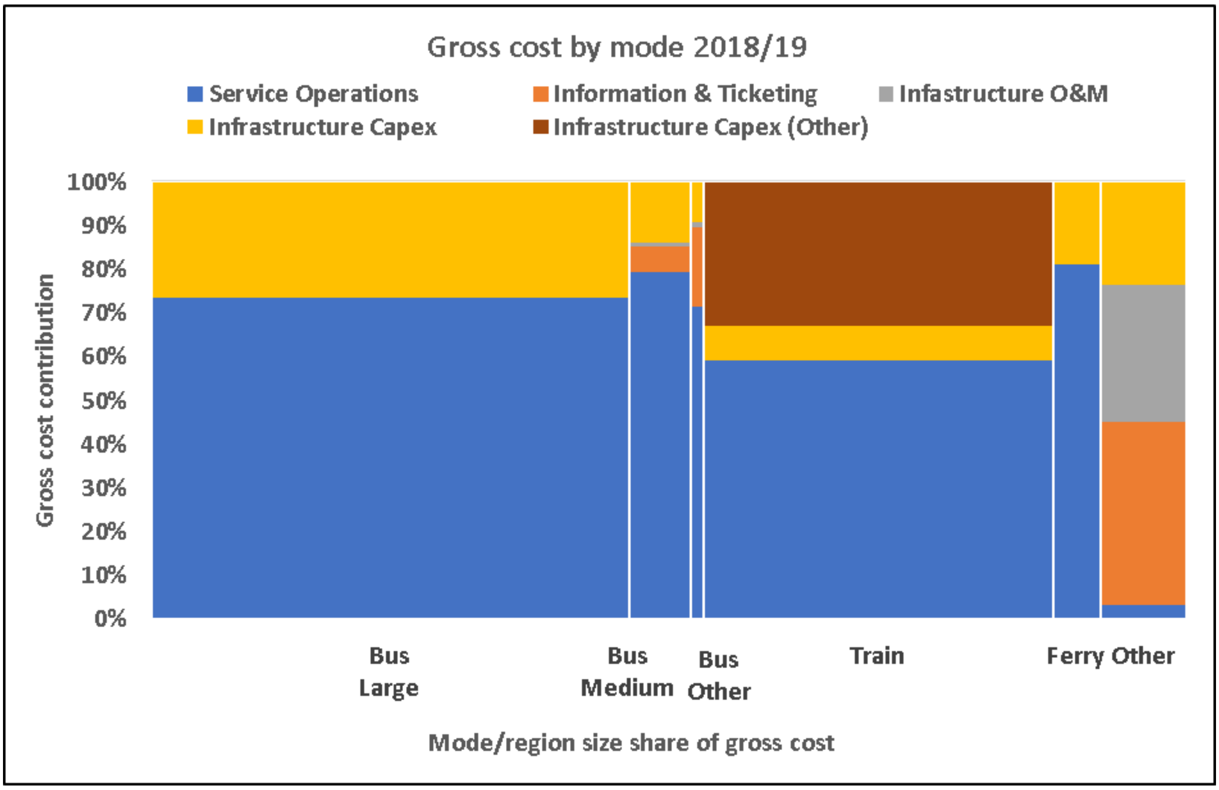
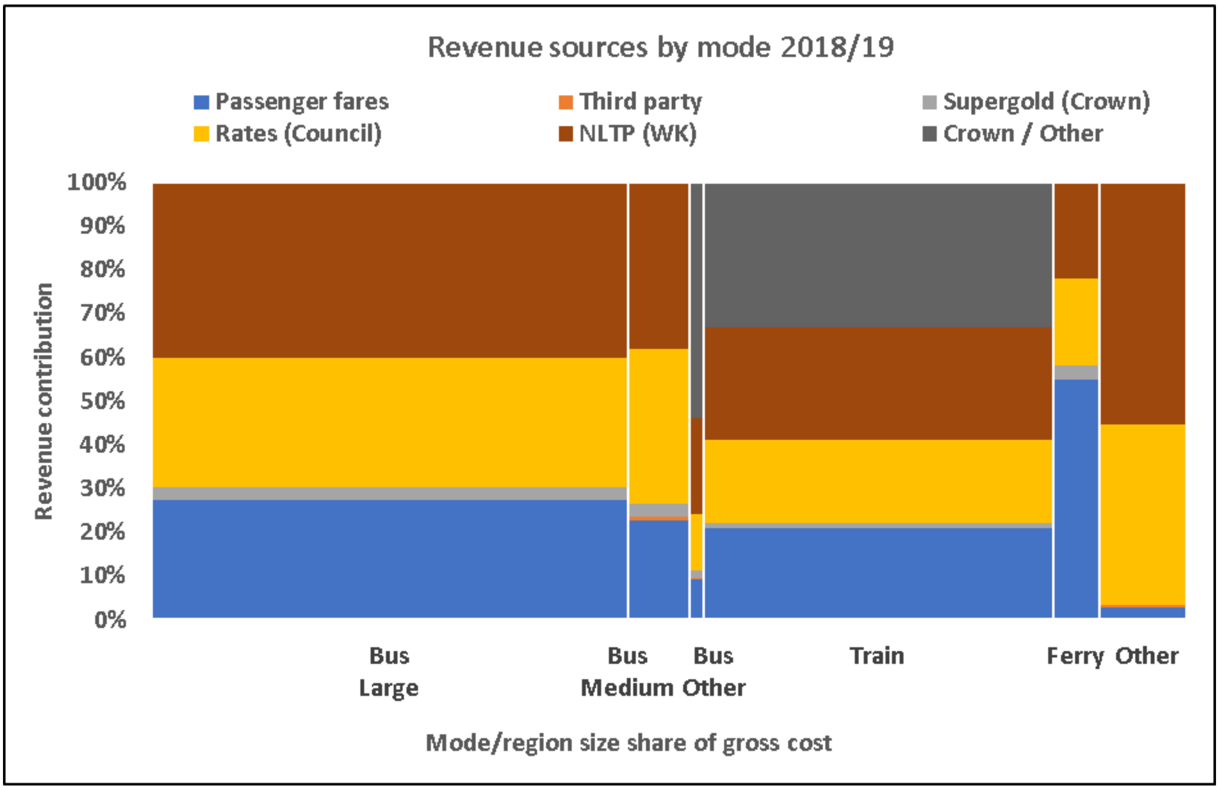


Figure 2.1.3 Revenue sources by mode 2018/19



2.2 Regional analyses

2.2.1 Costs and cost recovery

Figure 2.2.1 shows for each region the proportions of costs covered by user charges (fares) on two cost bases, i.e. (i) the proportion of opex costs only; and (ii) the proportion of total (including capex) costs[26]. On a national average basis, the overall financial cost recovery proportions were 34.4% on opex and 25.2% on total costs (including capex).

There is a tendency for the cost recovery proportions to be somewhat higher in the larger/medium-size regions, but this is not very pronounced. Only two regions, Wellington and Nelson, have cost recovery proportions significantly above the national average, with both regions having opex recovery of 40% and total cost recovery of 32%-33%. Of the larger regions, WLG leads the way with its 40% opex recovery, followed by AKL at 34% and CAN at 29%.

Most of the smaller regions have opex recovery proportions in the range 20% - 30%, with Nelson's 40% being a marked outlier.

Figure 2.2.1 Financial cost recovery by region

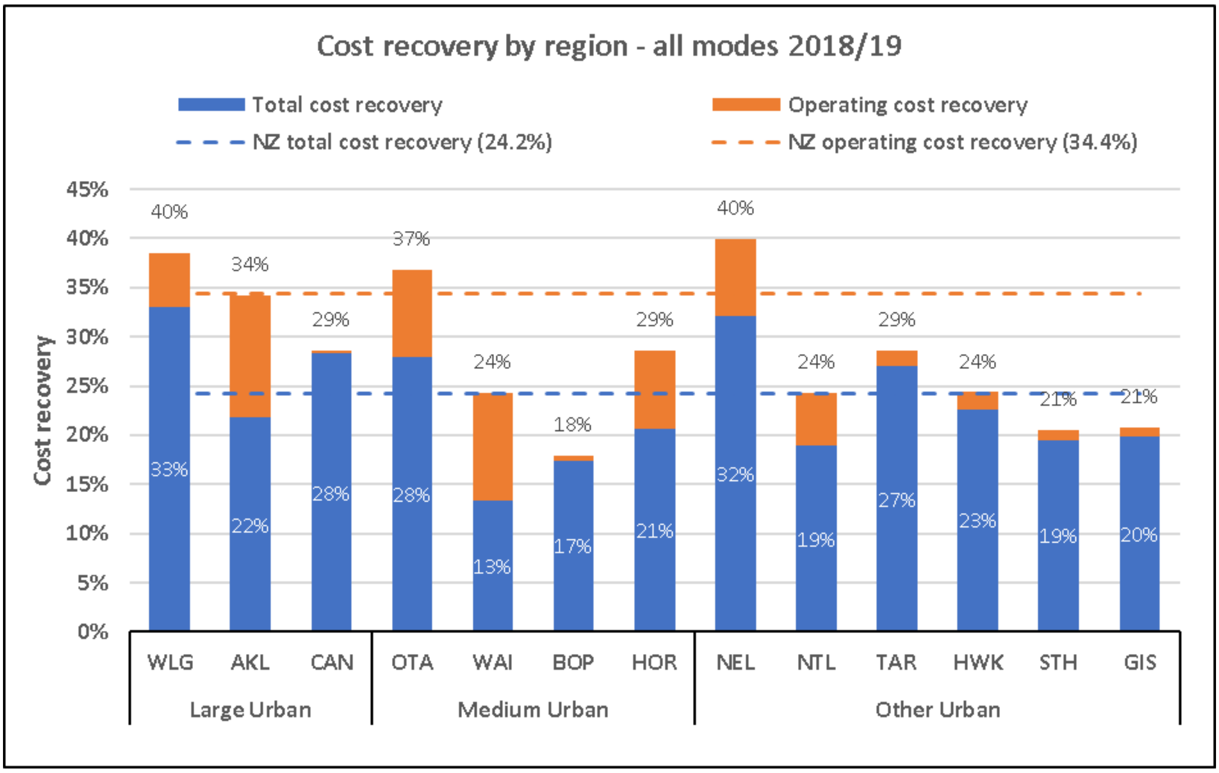


Figure 2.2.2 compares regions (and regional groups) by mode in terms of both their gross cost per boarding and their user contribution per boarding[27]. The gross costs/boarding average national figure is $8.77. The highest gross costs per boarding are clearly for the AKL train services ($15.58) followed by the WGN train services ($11.07) and the ferry (principally Auckland) services (average $10.15). When these costs are expressed per passenger km (Figure 2.2.3), the AKL train services

[26] The opex cost proportions are indicated by the total heights of the bars in Fig 2.2.1 and shown in dark lettering at the top of the chart. The capex cost proportions are indicated by the heights of the blue bars and marked in white lettering.

[27] User contributions are made up of passenger fares and third-party revenue received in lieu of fares, but excluding Supergold which is classified as Crown subsidy.

gross costs are still relatively high ($$1.28), while the WGN train cost rate ($0.46) is low relative to all the bus services.

The user contributions to total gross costs in most cases are in the range 23% to 40%, with the AKL Rail being particularly low (15%) and the ferry services overall being particularly high (55%). The Wellington cable car services are a prominent outlier, with very high costs on a per passenger km basis (on a very short route), but with close to 100% user cost recovery.

Figure 2.2.2 Gross cost and user contribution per boarding 2018/19

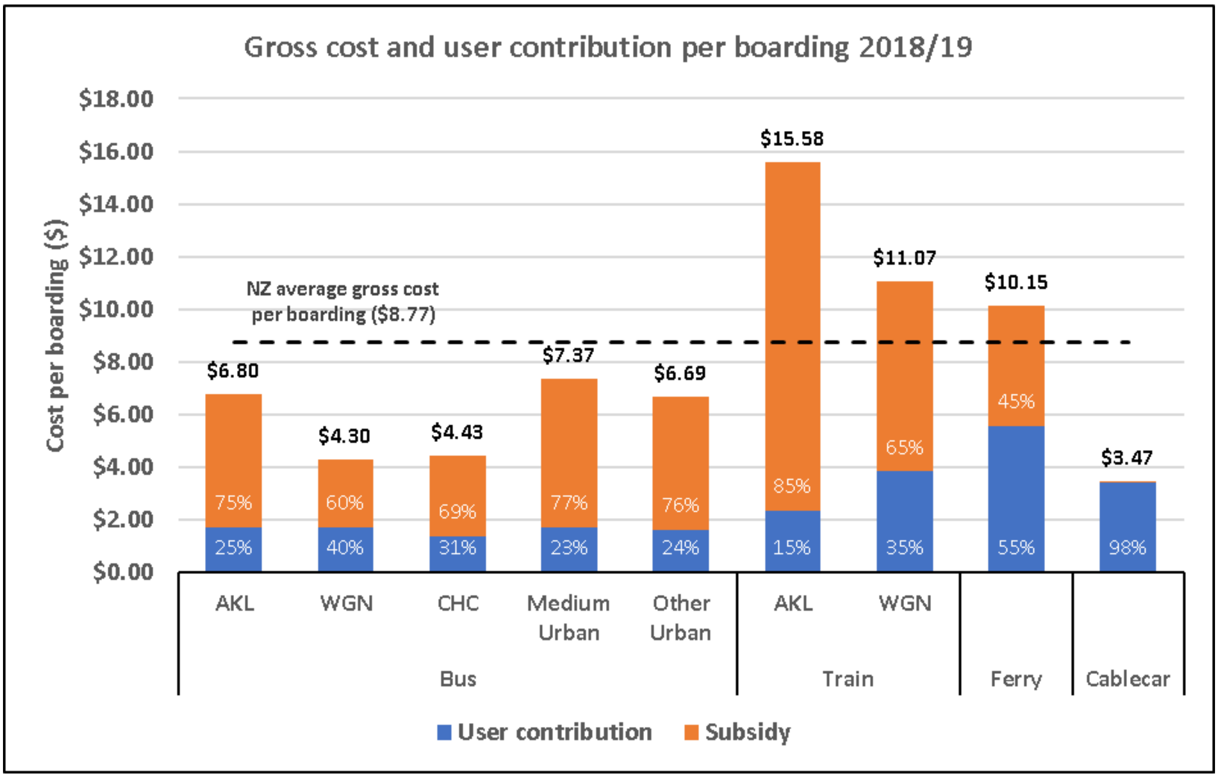
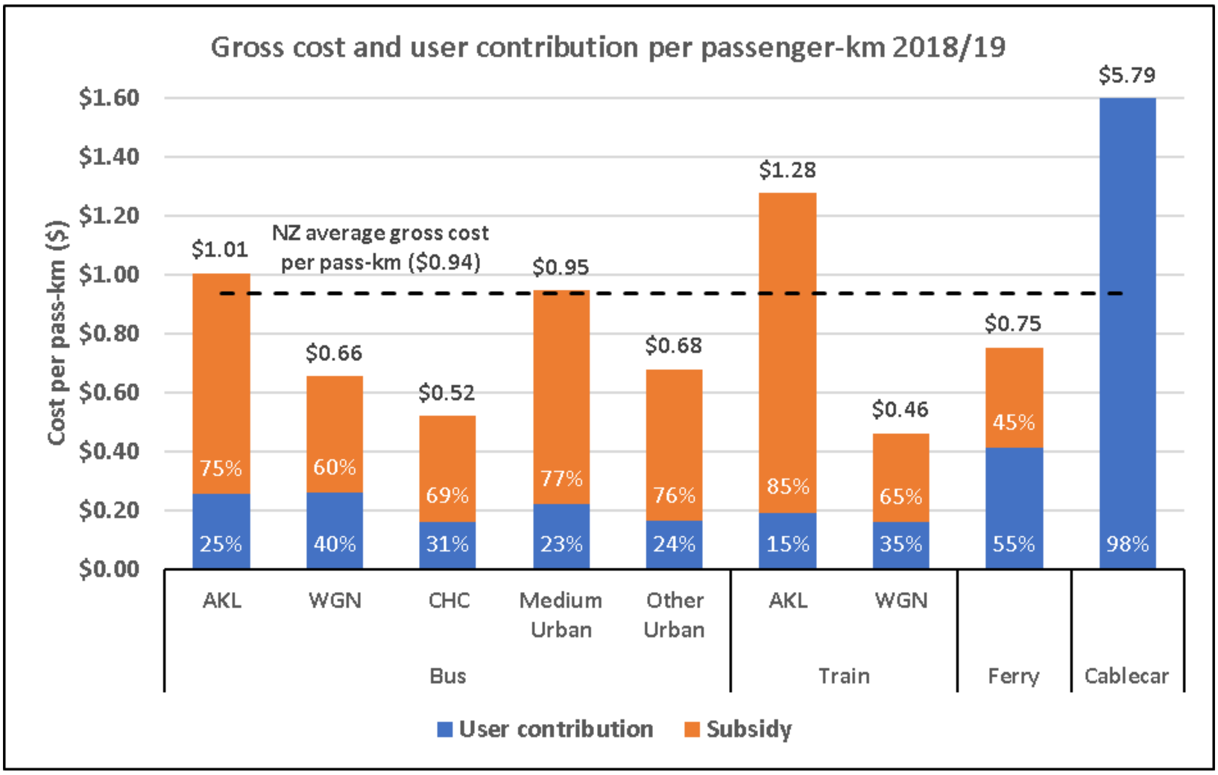


Figure 2.2.3 Gross cost and user contribution per passenger-km 2018/19



Figures 2.2.4 (bus) and 2.2.5 (train and ferry) show total gross costs (sum of the orange and blue bars) and net costs ((blue bars)by region, all on a per vehicle km (in-service) basis:

- Figure 2.2.4 (bus):
  - ***Gross costs/bus km***. These are highest (around $8-$9/bus km), by a substantial margin, in AKL and WGN, in part reflecting the relatively low average operating speeds resulting from traffic conditions and the longer boarding/alighting times (reflecting generally higher loadings in these regions). The lowest cost rates are for BOP, WAI and CAN, all at around $4/bus km.
  - ***Net costs/bus km***. As noted in relation to Figure 2.2.1 (above), typical user cost recovery levels on bus services are in the order of 25%, with the best performers being WLG (40%) and OTA (37%). The relative ordering of these net cost figures largely reflects that for the gross cost figures.
- Figure 2.2.5 (train, ferry and cable car):
  - ***Train.*** Gross costs/vehicle km are higher for AKL (c$80) than for WGN (c$50). The cost recovery performance is also higher for the WGN services, resulting in net costs/vehicle km of around $70 for AKL, $35 for WLG.
  - ***Ferry.*** Gross costs/vessel km are highest for AKL, reflecting the generally larger size of the ferries used in AKL. The AKL ferries also have a relatively high-cost recovery (around 50%), reflecting that a substantial proportion of the ferry services are operated on a commercial basis. The WLG, CAN and BOP ferry operations are relatively small, comprising essentially a single route in each of these centres. The WLG operation has a relatively high cost recovery, the BOP operation a ‘medium’ cost recovery, while that in CAN is relatively low.
  - ***Cable car.*** The WLG cable car has a very high cost per vehicle-km, in large measure reflecting that it is a very low speed operation relative to the other modes. Its cost recovery is relatively very high (over 90%), consistent with its role more as a

tourist service (with its own fare schedule) than as part of the regular PT network. Any comparisons of its performance with the other modes are of very limited value.

Figure 2.2.4 Gross and net costs per vehicle km – Bus

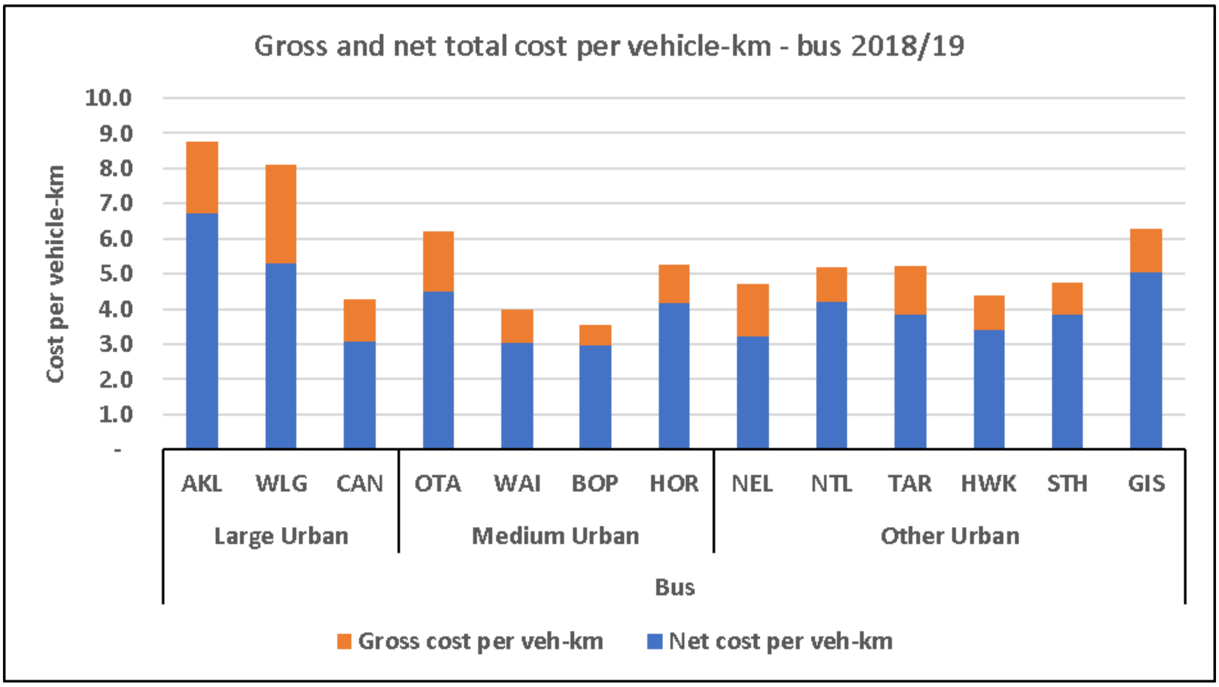
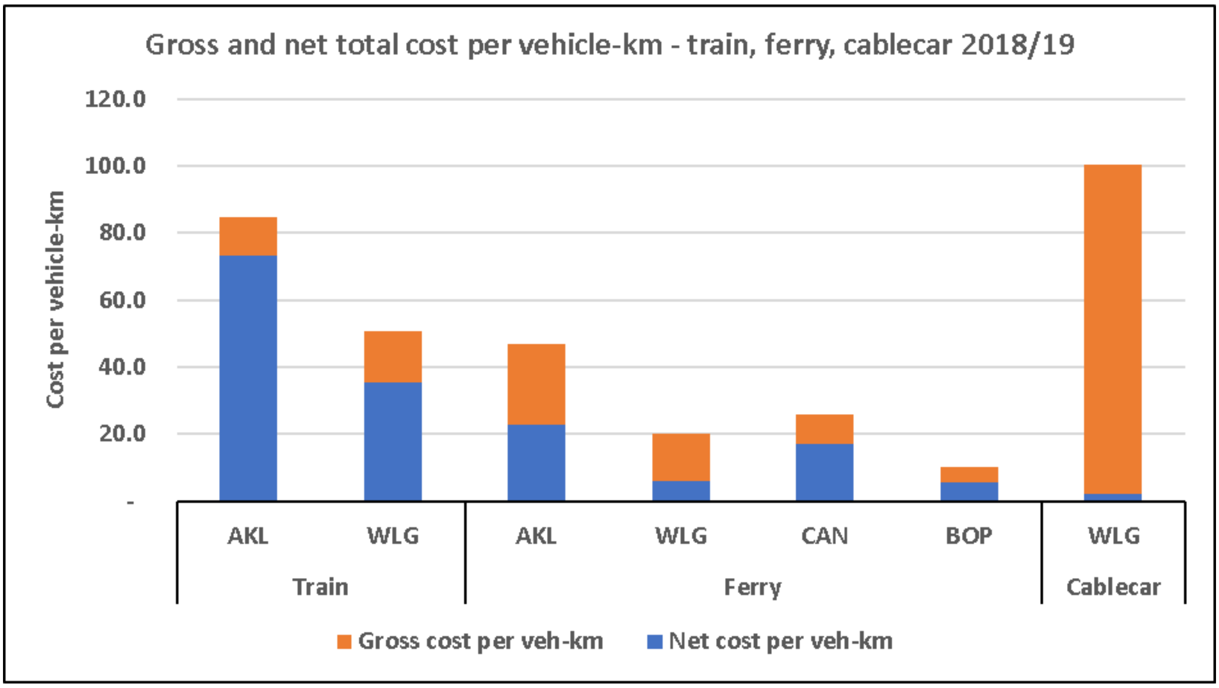


Figure 2.2.5 Gross and net costs per vehicle km – Train, Ferry, Cablecar



2.2.2 Patronage statistics by region and mode

Passenger boarding shares by region (Figure 2.2.6):

- This clearly shows the dominance of NZ's three major centres in terms of their use of public transport. AKL (59%), WLG (24%) and CAN (8%) together account for 91% of total national boardings.

- Of the other regions (together accounting for 9% of total national boardings), OTA, WAI and BOP each account for about 2% of national boardings, HOR around 1% and the other regions each less than 1%.

Passenger boardings per head of population (Figure 2.2.7):

- Consistent with Figure 2.2.6, this shows a strong correlation between boardings/population and the size of the populations in each region.
- The national average boardings/population ratio is 42 boardings pa. For the three regions with the largest urban centres, the average ratio is 59 boardings pa: the WLG figure is 78 boardings pa, the AKl figure is 63 boardings p.a. and the CAN figure is 27 boardings pa. WLG is notable for its relatively high usage figures when considered relative to AKL (with a population some three times larger) and to CAN (with a broadly similar population).
- The four ‘medium size’ regions in terms of their patronage contributions (OTA, WAI, BOP, HOR) have an overall average usage rate of 14 boardings pa; while the remaining six regions have an average rate of 5 boardings pa.

Figure 2.2.6 Share of total national public transport boardings, 2018/19

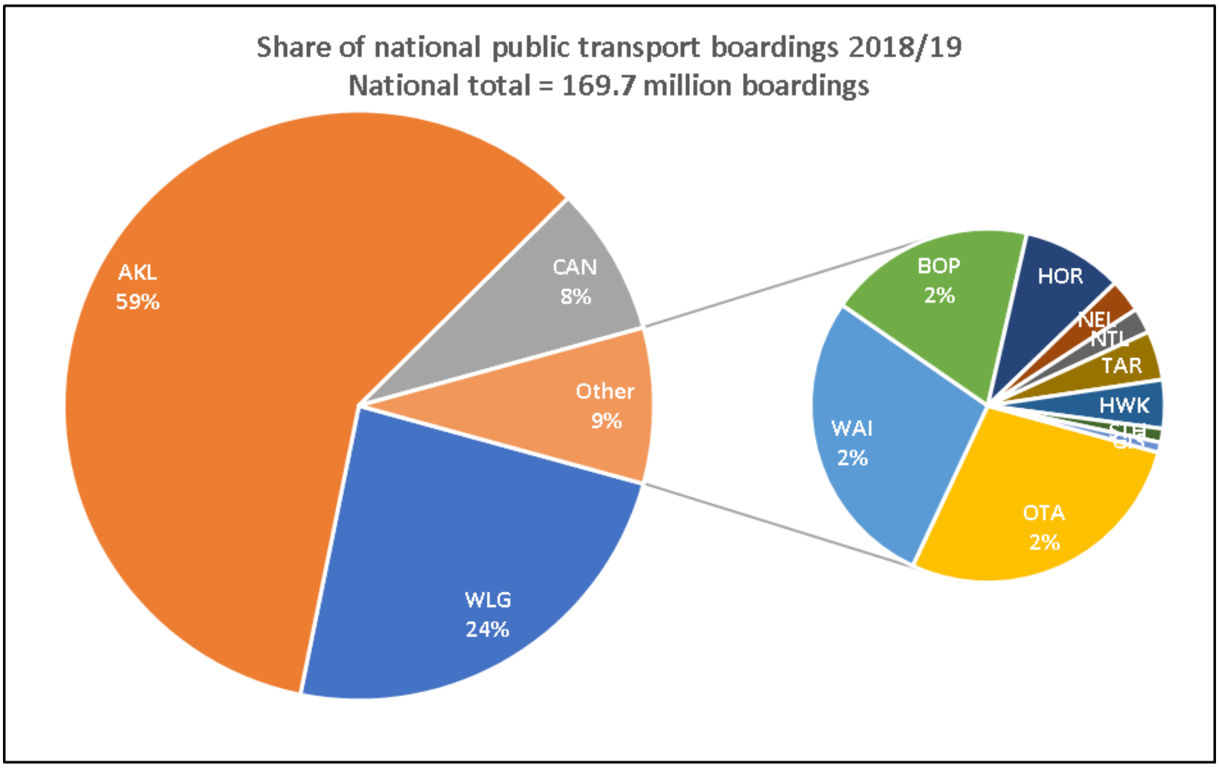
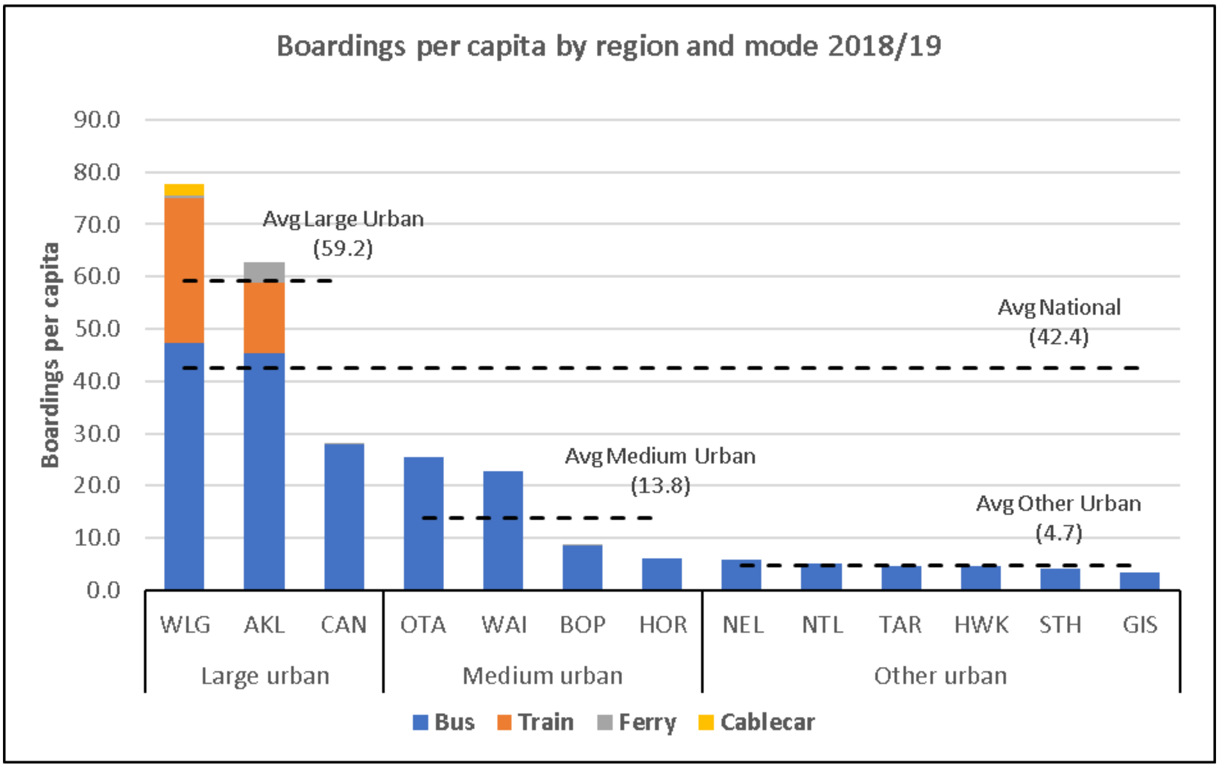


Figure 2.2.7 Boardings per capita by region and mode 2018/19

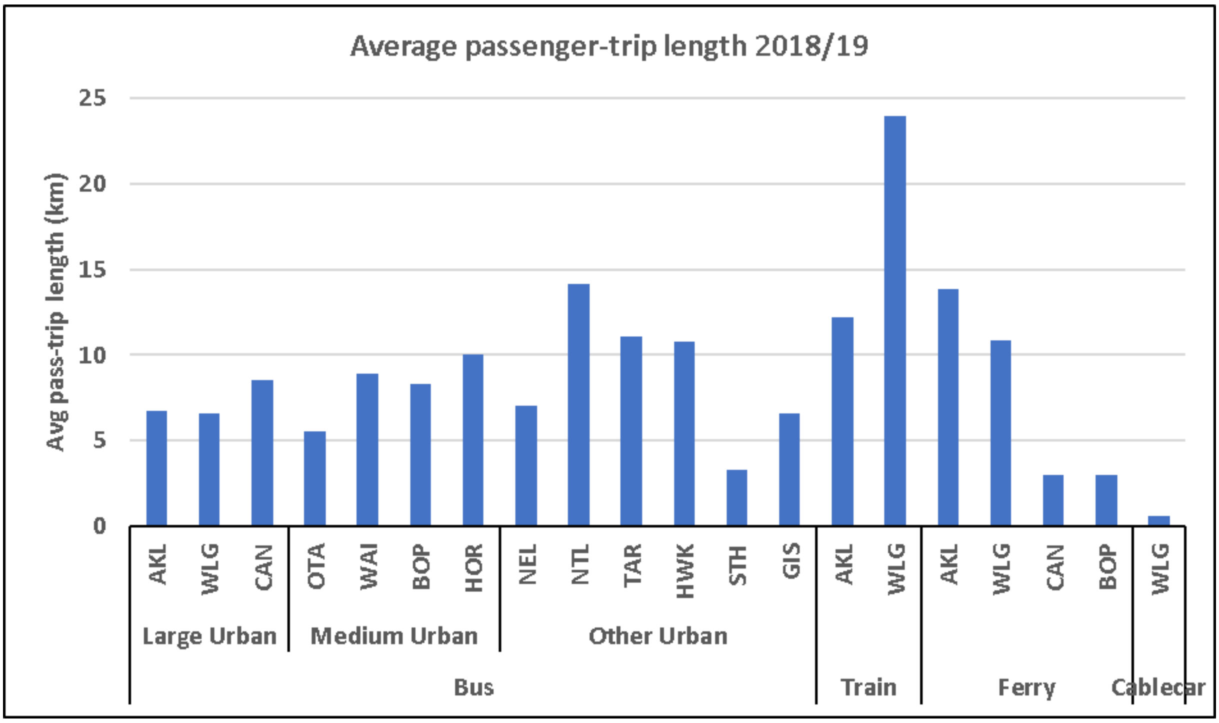


Passenger trip lengths (Figure 2.2.8). These figures measure the average distance travelled by passengers (based on passenger trip length distribution estimates obtained from Regional Councils) on each service, rather than their total journey distance (noting that some journeys may involve use of two or more services). These trip lengths are best considered by mode:

- ***Train.*** WLG trains have an average trip length of 23 km, which is large for a centre of its population size, but reflects the area's pattern of development, with the trains primarily serving linear developments in the Hutt Valley and the Kapiti Coast. By contrast, the average trip length on the AKL train services is 13 km, i.e. little more than half the WLG average.
- ***Ferry.*** The AKL ferry services (by far the largest ferry operations in NZ) have an average trip length of 14 km -- which reflects a wide mixture of shorter and longer routes. The WLG ferry essentially covers a single cross-harbour route (11 km), and similarly with the CAN ferry (although on a much shorter route).
- ***Bus.*** The bus trips in most of the urban areas average between 6 km and 12 km in length. The bus trip lengths in AKL and WLG are towards the bottom end of this range, around 7 km in each case, which is relatively short for centres of their size: this reflects that a substantial proportion of the longer trips in these centres are provided by train (in both centres) and ferry (primarily in AKL)[28]; and that many longer journeys by bus will involve the use of two or more services.

[28] This is consistent with the policy that trains provide for longer-distance movements and generally do not duplicate coverage of bus routes.

Figure 2.2.8 Average passenger trip lengths by mode & region



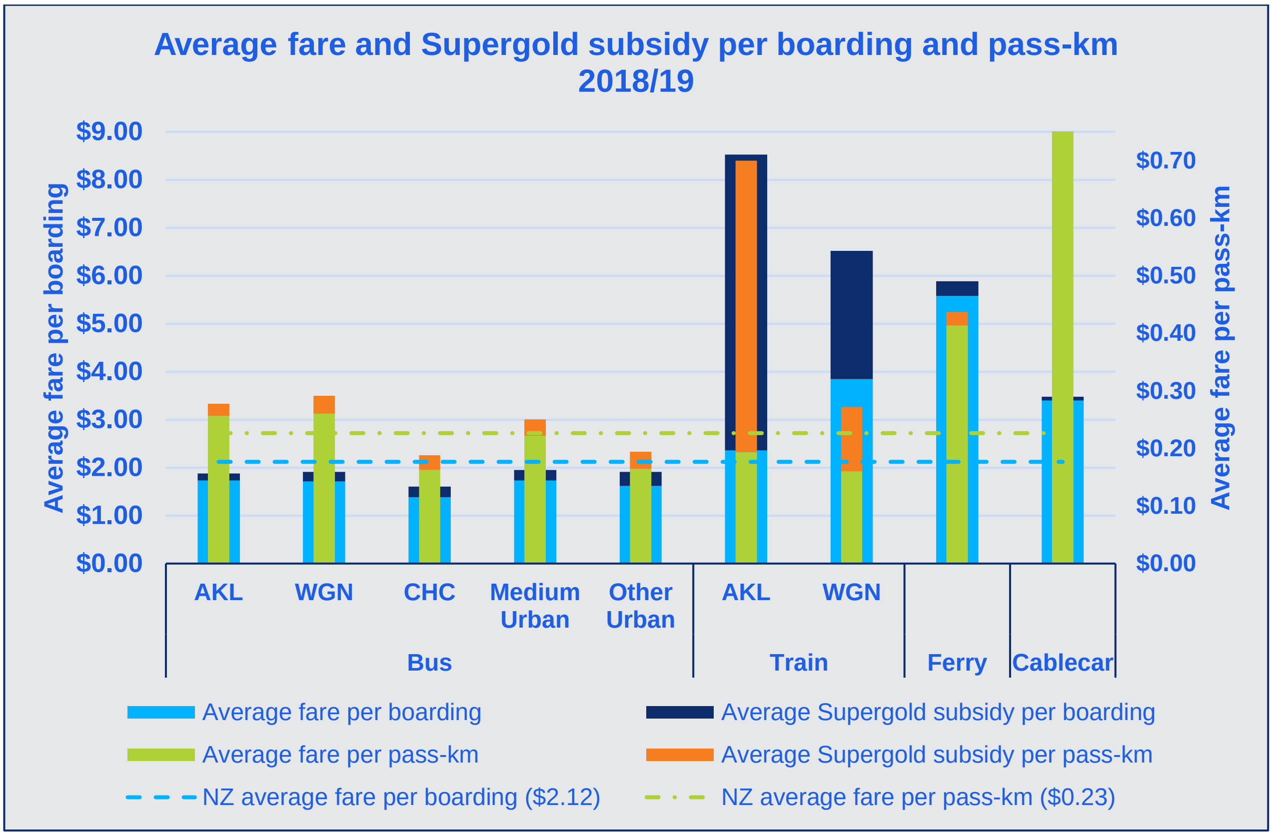
2.2.3 Fare levels

Figure 2.2.9 provides an overview of fare levels (and Supergold payments) by PT mode (bus, train, ferry) and by group of regions. For each region/group, it gives information on average fares per boarding and per passenger km.

Key features of these results include:

- On an aggregate national basis (all PT modes), average fares per boarding were $2.12, or alternatively expressed as $0.23 per passenger km (with an average trip length of some 9 km).
- Average bus fares (per boarding) appeared to be generally similar in most centres (but relatively low in CAN), with the corresponding fare/km tending to be rather higher in those centres with shorter trip lengths.
- Train fares per boarding tend to be somewhat higher than the bus fares in the same region, in large measure reflecting longer trip lengths by train; but they tend to be lower on a per passenger km basis.
- Ferry fares are substantially higher than bus and train fares on both a per boarding and per passenger km basis. These higher fares most likely reflect the commercial nature of a large proportion of the ferry services in AKL and also the relative levels of competition from other modes for most of the ferry passenger market.

Figure 2.2.9 Average fares per boarding and passenger-km by mode & region



2.2.4 Vehicle occupancy levels

Figure 2.2.10 (bus) and Figure 2.2.11 (train and ferry) show average occupancy (utilisation) levels (derived from length of each route applied to the timetable data) , measured as passenger kilometres/vehicle kilometres for each region. It should be noted that these figures are annual averages, averaged over the total length of each route, over both directions and over all times of day[29].

Taking a 40-seater bus as an example, in the AM peak period the inbound services will start from the outer terminal with no passengers and gradually fill up (with say 40 passengers) by the time it reaches the CBD -- hence a broad average of around 20 passengers over its whole trip. Outbound services in the AM peak period will typically carry very few passengers, say zero. The average peak period occupancy over both directions will therefore be around 10 passenger km/vehicle km. In the off-peak periods, the loadings will be more balanced in both directions but very few bus trips will carry as many passengers as an all-seated load: on average, the off-peak services would have similar occupancy levels to the peak periods, i.e. around 10 passenger km/vehicle km. So this average occupancy level provides a good guide to a well-used urban bus operation in the NZ context.

For train and ferry services, we did not have readily-available data on average vehicle capacities (with or without standees) to be able to compare passenger kilometres with available capacity kilometres.

[29] The figures given do not take account of any 'not in service' bus running (which typically adds around 10-15% to the service running figures).

- ***Bus services (Figure 2.2.10).*** Only one region (WLG) has average (in service) bus occupancy above 10.0 passenger km/vehicle km (when in service). Four other regions (AKL, HOR, NTL and TAR) have average bus occupancy levels between 8.0 and 9.0. At the other end of the scale, a further five regions (OTA, WAI, BOP, NEL and SOU) have average bus occupancies of 6.0 or lower.
- ***Train services (Figure 2.2.11).*** WLG has the highest average occupancy levels, at around 95 passenger km/vehicle km, with AKL significantly lower at some 60 passenger km/vehicle km. A major reason for the higher occupancy levels in WLG is that a large proportion of its rail passengers start their inbound trips in the more distant parts of the region and therefore occupy a seat for most of the distance run by the train to Wellington CBD; whereas in AKL a greater proportion of the rail trips are over relatively short distances.

  Note that: (i) the 'vehicle km' measure used here relates to the whole train rather than to each unit or carriage; and that: (ii) in general, the peak-period peak-direction trains in both centres are well loaded (i.e. most of the seats are filled at the point of maximum loading, and with significant proportions of standing passengers on some services).
- ***Ferry services (Figure 2.2.11).*** Given their largely point-to-point nature, ferry service occupancy levels could be expected to be higher (relative to the number of seats provided) than the corresponding levels for bus and train services. For AKL, the chart indicates that its average ferry occupancy level, at about 60 passenger km/vehicle km is about on the par with its average train occupancy level; whereas the average ferry occupancy levels in the other three regions (WLG, CAN, BOP) are in the order of twice each region's bus occupancy levels.

Figure 2.2.10 Average vehicle utilisation by region – Bus

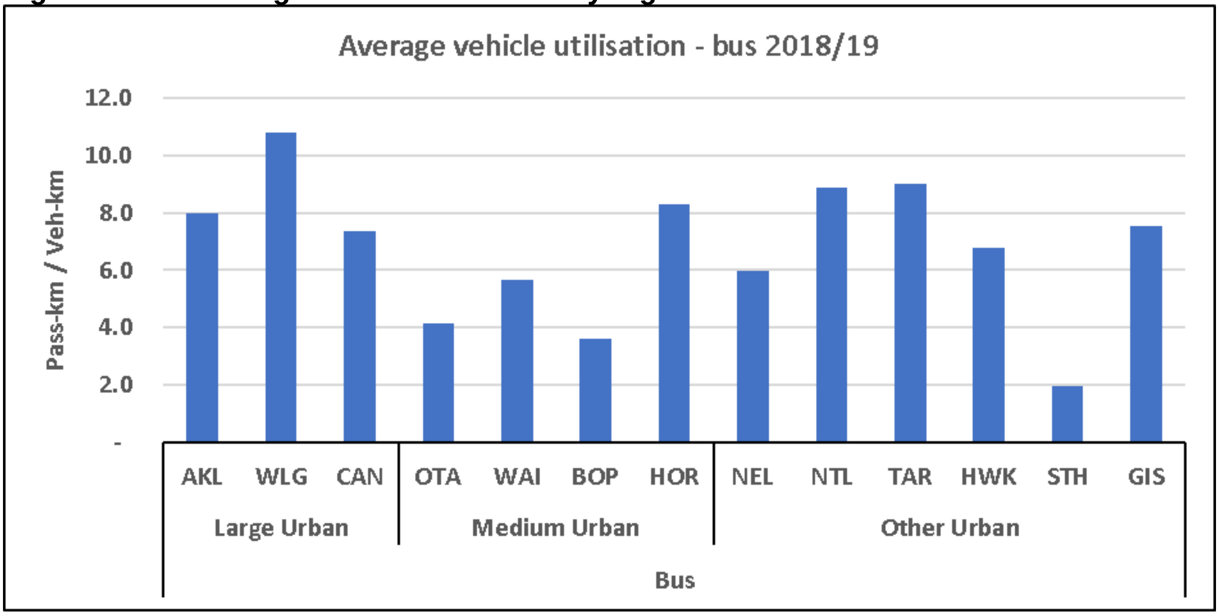
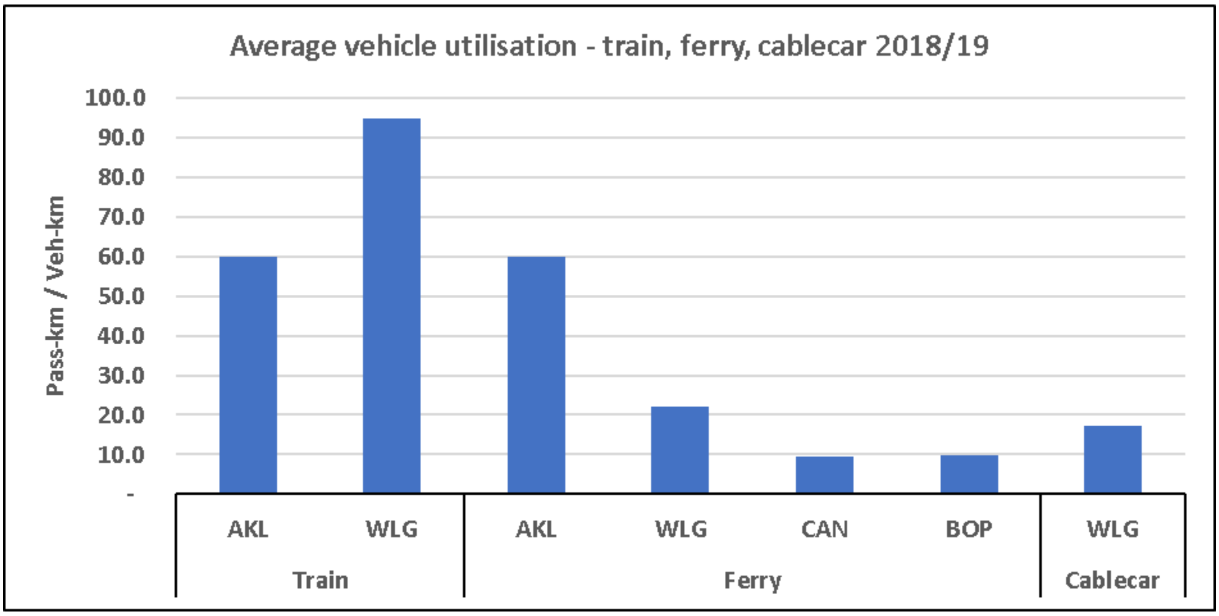


Figure 2.2.11 Average vehicle utilisation by region – Train & Ferry


Average vehicle utilisation - train, ferry, cablecar 2018/19
Pass-km / Veh-km
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
-
AKL
WLG
AKL
WLG
CAN
BOP
WLG
Train
Ferry
Cablecar

Chpater 3 Wellington Rail – costs and charges analysis

3.1 Introduction

This chapter provides an analysis of the aggregate costs[30], the user charges (fares and associated revenues) and the resultant public funding (subsidies) for the Wellington metropolitan rail system in 2018/19[31].

Following this introductory section, this chapter is structured as follows:

- Section 3.2 - outlines our analyses of the current rail operations
- Section 3.3 - sets out our analyses of the rail operating costs (including capital charges) and derives a set of unit variable costs
- Section 3.4 - provides our analyses of patronage and revenue statistics by train line and peak/off-peak periods
- Section 3.5 - presents and comments on our overall results, including coverage of financial performance by line and time period, of marginal cost functions and of our approach to estimation of marginal costs.

We note here that, given the broad similarities in terms of cost and revenue structures between the Auckland and Wellington rail systems, detailed analyses of the type presented here have not been undertaken for the Auckland metropolitan rail system -- although more aggregate-level analyses for the Auckland system are included in chapter 2 of this working paper.

We would like to express our thanks to GWRC for their support and assistance in this work, in terms of their provision of extensive data and responding to numerous consultant queries.

3.2 Data and Analyses -- Operations

A database of the existing rail operations was assembled and analysed, as a key ‘building block’ in the allocation of costs by rail line, line segment and time period. Table 3.2.1 provides a summary of this database and the analyses undertaken to provide key operational statistics for costing purposes.

Figure 3.2.1 provides a diagrammatic view of the Wellington rail network. The rail lines and line ‘segments’ used in the analyses, together with the relevant line distances, are set out in Table 3.2.2. Figures 3.2.2A (train requirements) and 3.2.2B (car requirements) show the number of trains and the number of cars in operation by line/line segment throughout weekdays[32]. The very ‘peaked’ nature of the operations, particularly in terms of cars in service, is very evident from figure 3.2.2B: the peak ‘cars in-service’ requirement is 152 cars (132 EMU cars plus 20 loco-hauled carriages on the Wairarapa line) in the AM peak period (and 144 cars maximum in the PM peak); while the minimum requirement in the weekday inter-peak period reduces to a minimum of 22 cars (around 12:30). Such a 6:1 ratio represents a very peaked service in terms of patterns of capacity supplied: a more typical NZ ratio for urban bus services is around 2:1.

[30] The costs covered in this chapter (and throughout this paper) are essentially financial costs: they include annualised capital charges (depreciation and interest) for the assets involved, calculated consistently with the assumptions used by GWRC for accounting purposes. Social and environmental costs are not covered here, but are addressed in other DTCC papers. Further discussion on cost coverage and interpretation is included in Section 2.1.1.

[31] This paper covers the electrified (EMU) passenger services in the Wellington region and the diesel-hauled services between Masterton (Wairarapa) and Wellington. It does not include the ‘Capital Connection’ services between Palmerston North and Wellington

[32] All cars operate in permanently coupled 2-car sets, with up to 4 sets coupled to form up to 8-car trains for peak period services.

Table 3.2.3 provides a summary of operating resources required, on an annual basis, by line and time period (peak /off-peak)..

Table 3.2.1: Operations data and analyses - summary

Title	Summary description	Notes
Service Source	Scheduled timetable service statistics.	GTFS feed for June 2019 period as published by GWRC.
Service Data	Detailed working timetables and operational details (including consist sizes), definition of peak/off-peak services and calculation of annualised service statistics (train hours, unit kms etc),	Working timetable provided by GWRC and combined with GTFS service data. Peak/off-peak: All weekday trips departing before 9am and between 3pm and 6.30pm are allocated to peak. All other trips including weekends are categorised as off-peak. Passenger operators: Assumed 1 per JVL train irrespective of number of cars; otherwise 0 per train with less than 6 cars, 2 per train with 6 cars, 3 per train with 8 cars.
Service PVR (note 1)	Calculation of number of trains and train-cars in motion/operation by period and line/segment; used to estimate peak train/car requirements (note 2).	Peak cars adjusted to control totals provided by GWRC. Reported off-peak cars requirement is based on weekday interpeak requirement (excluding shoulder periods).
Service Summary	Summary of annual service statistics (trains and units in operation, train hr, train km, unit hr, unit km) by peak vs off-peak, line/segment	Used as inputs into cost allocation.

Notes:
1. PVR = peak vehicle requirements (i.e. number of trains and train cars required to operate the peak period services).
2. The term ‘peak trains’ refer to the number of trains required to cover the peak period operation, and ‘peak cars’ refer to the number of cars (carriages) required to cover the peak period operation.

Table 3.2.2: Line and line segment definitions for service and cost analyses (1)

Line (designation)	Line segment (designation)	Line distance - kms
Kapiti (KPL)	Porirua (POR)	17.7
	Plimmerton (PLIM)	24.4
	Waikanae (WAIK)	55.3
Hutt Valley (HVL)	Melling (MELL)	14.1
	Taita (TAIT)	20.5
	Upper Hutt (UPPE)	32.4
Johnsonville (JVL)		10.3
Wairarapa (WRL)		91.0

Note: (1) Outside peak periods, all services run the full length of the relevant line. In weekday peak periods, a 3-tier service is operated on the Kapiti and Hutt Valley lines, with a substantial proportion of the services providing ‘short runs’ over a line segment, not covering the full line length.

Figure 3.2.1 Wellington rail network diagram (showing fare zones)

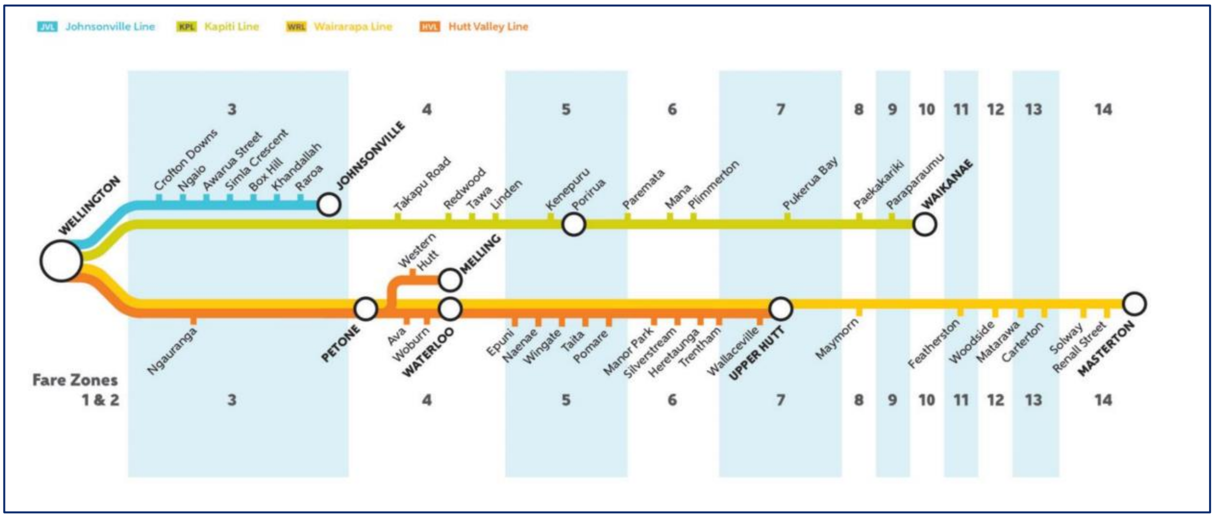


Table 3.2.3: Summary of annual operating resources required by time period and line

Period	Line	Wellington Train 2018/19						
		Peak trains (#)	Train-hrs (#000)	Train-kms (#000)	Peak cars (#)	Car-hrs (#000)	Car-kms (#000)	Pass-op-hrs (#000)
Peak	HVL	14	13.9	714	70	69.9	3,651	17.8
	KPL	10	13.9	781	60	72.2	4,067	17.2
	JVL	5	5.0	124	20	20.1	494	5.0
	WRL	2	3.0	159	20	20.1	1,047	7.0
Peak subtotal		**31**	**35.8**	**1,778**	**170**	**182.2**	**9,259**	**47.0**
Offpeak	HVL	6	16.8	736	12	40.8	1,784	2.3
	KPL	6	20.9	1,164	12	51.6	2,865	2.0
	JVL	2	6.8	182	4	15.2	405	0.8
	WRL	2	2.2	119	12	13.2	715	4.4
Offpeak subtotal		**16**	**46.8**	**2,201**	**40**	**120.8**	**5,770**	**9.4**
Total	HVL	14	30.7	1,450	70	110.7	5,435	20.1
	KPL	10	34.9	1,945	60	123.8	6,932	19.2
	JVL	5	11.8	306	20	35.3	900	5.8
	WRL	2	5.3	278	20	33.3	1,762	11.4
Grand total		**31**	**82.6**	**3,979**	**170**	**303.0**	**15,029**	**56.5**

Figure 3.2.2A: Train requirements by time-of-day (weekdays)

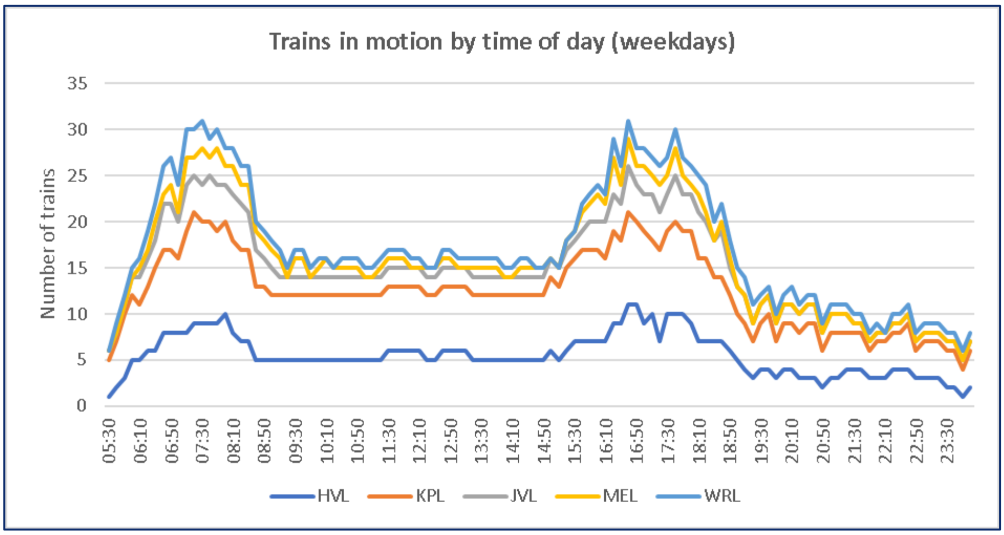
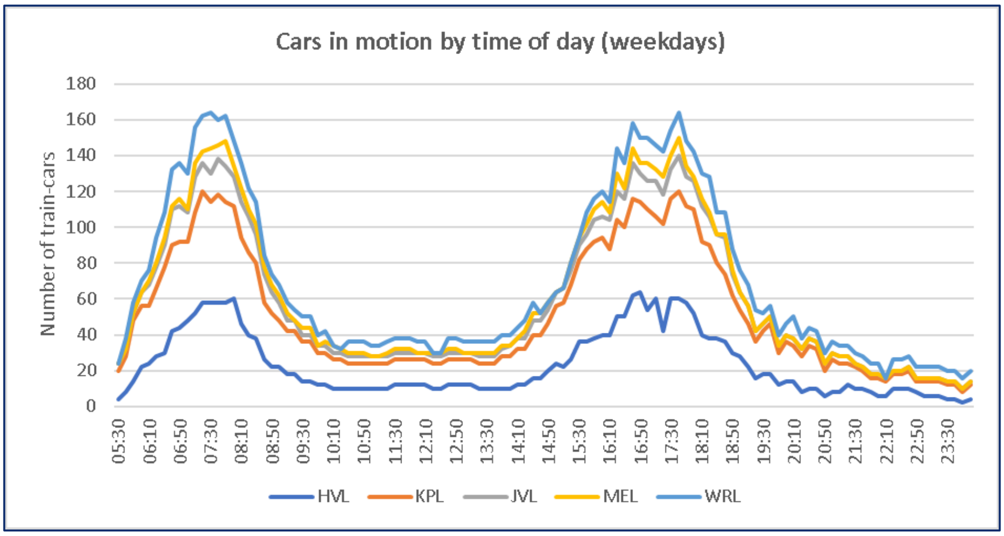


Figure 3.2.2B: Car requirements by time-of-day (weekdays)



3.3 Data and Analyses -- Costs

3.3.1 Operating costs

Our analyses of the WLG rail operating costs are based on the financial statements in the GWRC 'Wellington Metropolitan Rail 2018/2019 Annual Report' (June 2019)[33]. Table 3.3.1 provides a high-level summary of the relevant operating costs (with a more detailed breakdown given in Table 3.3.3). The total operating costs (excluding capital charges) for 2018/19 were $112.77 million.

[33] For convenience, the Wellington Metropolitan Rail 2018/19 report is referred to in this paper as WMR (2018/19). As the WMR estimates do not include any economic capital charge, our total combined costs of $148.05 million differ from any figures given in WMR.

Table 3.3.1: Summary of rail operating costs and capital charges 2018/19		
Cost item	**Cost - $mill**	**Notes**
Operating costs:		
Rail operations	60.669	Most of these costs are payments to Transdev for the operating contract.
Network operations and access	34.850	Most of these costs are payments to KiwiRail for network operations, maintenance and renewals Includes network traction electricity ($4.452 m)
Occupancy costs	5.173	These costs relate mainly to station expenditures, security, lease charges and rates
Metlink & mgt services	12.078	Comprises GW common services (information, ticketing etc) and management overheads
Total operating costs	**112.770**	
Capital charges:		
Depreciation - rolling stock	13.398	Depreciation charges as given in WMR p59 note 6
Depreciation – stations etc	3.041	
Capital charge - rolling stock	14.613	Economic capital charges calculated as 4% of the depreciated asset values (values given in WMR p59 note 6)
Capital charge – stations etc	4.230	
Total capital charges	**35.283**	
Grand total costs	**148.053**	

3.3.2 Capital charges

Our assessment of relevant capital charges in the DTCC context is also summarised in Table 3.3.1. We comment as follows:

- ***Depreciation.*** At June 2019, the Matangi EMUs accounted for around 80% of the total value of assets involved in the provision of the WGN rail services. There were acquired in around 2010 (tranche 1) and 2015 (tranche 2). We understand that GWRC's policy is to depreciate them on a straight-line, historic cost basis over their assumed effective life of 30 years. The nature of this asset is such that any estimate of its market value is fraught: on the one hand, their re-sale value is very low, as the international market for second-hand narrow-gauge rolling stock is very limited; on the other hand, their ongoing value to GWRC as a continuing rail operator is relatively high, as the possibility of purchasing suitable replacement (second-hand) stock is very low. Given this dilemma, for the purposes of our analyses, we have used the WMR 2018/19 figures as the basis for calculating both depreciation and capital charges (see the following).
- ***Economic capital charge.*** Consistent with our approach adopted throughout DTCC, we allow for an annual capital charge (opportunity cost of capital) of 4% of the economic value of the assets -- which in this case we take as equal to the written-down value used for accounting purposes.
- The resultant depreciation and capital charge values are given in the lower section of Table 3.3.1 (further details given in Table 3.3.3). The total capital charges for 2018/19 were $35.28 million. The capital charges and operating costs combined totalled $148.05 million.[34]

The resultant depreciation and capital charge values are given in the lower section of Table 3.3.1 (further details given in Table 3.3.3). The total capital charges for 2018/19 were $35.28 million. The capital charges and operating costs combined totalled $148.05 million.[35]

3.3.3 Cost allocation and unit costs

To analyse the financial performance of the rail services (by line, time period etc), in this section we assume that all costs are directly variable with one or other (the most appropriate) measure of output. (Potential variations to this assumption are discussed in subsequent sections.)

For this purpose, six potential measures of output were considered, as summarised in Table 3.3.2.

Table 3.3.2: Output measures considered for cost allocation

Output measure	Notes
Trains in service (peak)	Relevant to peak period train requirements only
Cars in service (peak)	Relevant to peak period car requirements only
Train hours	
Car hours	
Car kilometres	
Passenger operator hours	This is related to train hours and car hours, as the requirements for passenger operators depend on the cars per train and also differ by line.

Given that the type of operation on the Wairarapa services (loco-hauled carriages) differs from that on all the other lines (EMUs), it was necessary to split each cost item into one of three categories: applicable to Wairarapa services only; applicable to EMU services only; or applicable similarly to all services.

Table 3.3.3 sets out our cost allocation assumptions for the main 20 or so cost categories (together accounting for the total costs), showing for each (i) the split of costs between the EMU (metro) services and the Wairarapa services; and (ii) the most appropriate measure(s) of output. It will be noted that:

- A number of cost categories are allocated across more than one output measure (e.g. 50% train hours, 50% peak trains).
- Management etc costs have generally been allocated on the same basis as the ‘direct’ (e.g. labour) costs to which the management relates.
- Higher level/indirect overhead costs (principally the item for Metlink/GW management services overheads) have been allocated in proportion to the more direct costs.
- All capital charges have been related to the peak car requirement (separately for EMU/metro services and Wairarapa services), noting that (i) the great majority of these charges are for the Matangi rolling-stock, and (ii) the Wairarapa carriages involve only small depreciation and capital charges, reflecting their age.[36]

[36] We note that the locomotives used to operate the Wairarapa services are owned by KiwiRail and accounted for under the ‘loco hire’ operating cost item (rather than under the capital charges).

Table 3.3.3 Cost allocation[37]

	Cost allocation 2018/19 ($000)			Allocation basis	
Cost categories	**Metro**	**WRL**	**Total**		**Notes**
Rail operations	**51,884**	**8,785**	**60,669**		
Passenger services (Transdev):	**41,720**	**2,505**	**44,225**		
Train drivers	10,879	-	10,879	Peak-trains	
Train managers/guards	7,040	478	7,518	Train-hrs	
Passenger operators	2,223	563	2,786	Pass-op-hrs	
Terminal operations	1,367	93	1,459	Train-hrs	Split 50:50 between train-hrs and peak-trains
Labour - admin and management	9,442	641	10,083	Train-hrs	Split 50:50 between train-hrs and peak-trains
Passenger other costs and overheads	10,768	731	11,499	Train-hrs	Split 50:50 between train-hrs and peak-trains
Allocate proportion of costs to Peak-trains	-10,788	-732	-11,521	Train-hrs	Split 50:50 between train-hrs and peak-trains
Allocate proportion of costs to Peak-trains	10,788	732	11,521	Peak-trains	Split 50:50 between train-hrs and peak-trains
Vehicle services (Transdev):	**10,103**	**1,681**	**11,784**		
Matangi Planned and Unplanned Mtce	4,007	-	4,007	Car-hrs	
Carriage Planned and Unplanned Mtce	-	907	907	Car-hrs	
Other Maintenance Costs	168	21	189	Car-hrs	
Management & Admin Labour	2,035	251	2,286	Car-hrs	
Fleet Cleaning	1,414	189	1,603	Peak-cars	
Depot Cleaning	645	86	731	Peak-cars	
Maintenance Management Systems	304	38	342	Car-hrs	
Inventory Financing	860	106	966	Car-hrs	
Other costs	671	83	754	Car-hrs	
Loco hire	**-**	**4,591**	**4,591**		
Loco hire (KRG-Yrapa service)	-	4,591	4,591	Peak-trains	Main items loco hire charge (mainly cap), drivers, loco R&M, fuel
Allocate proportion of costs to Train-hrs	-	-1,148	-1,148	Peak-trains	Split 75:25 between peak-trains and train-hrs
Allocate proportion of costs to Train-hrs	-	1,148	1,148	Train-hrs	Split 75:25 between peak-trains and train-hrs
Other opns expenses	**61**	**8**	**69**	**Car-kms**	
Network operations and access (KRG):	**31,297**	**3,553**	**34,850**		
Network traction electricity	**4,542**	**-**	**4,542**	**Car-hrs**	
Network opns and mtce	**13,573**	**1,802**	**15,375**		
N/w mgt services	3,926	521	4,447	Car-kms	
N/w control	1,570	209	1,779	Car-kms	
Mtce	5,691	756	6,447	Car-kms	
N/w overheads	901	120	1,021	Car-kms	
KRG overheads	51	7	58	Car-kms	
Other charges	1,555	207	1,762	Car-kms	
Revenue	-122	-16	-138	Car-kms	
Network renewals	**13,182**	**1,751**	**14,933**		
Track	8,217	1,091	9,308	Car-kms	
Civils	656	87	743	Car-kms	
Structures	281	37	318	Car-kms	
Signals	891	118	1,009	Car-kms	
Telecommunications	239	32	271	Car-kms	
Slopes and sea-walls	153	20	174	Car-kms	
Traction	962	128	1,090	Car-kms	
Platforms	252	33	285	Car-kms	
Route access	1,472	196	1,668	Car-kms	
Level crossings	59	8	67	Car-kms	
Occupancy costs (GW):	**4,564**	**609**	**5,173**		
Wellington Stn occupancy	1,106	148	1,254	Peak-cars	Mostly stations
Station expenditure	2,474	330	2,804	Peak-cars	Mostly stations
Leases and rates	280	37	317	Peak-cars	Mostly stations
Insurance	472	63	535	Peak-cars	Mostly stations
Security	232	31	263	Peak-cars	Mostly stations
Metlink & Mgt Services Overheads (GW):	**10,475**	**1,603**	**12,078**		Allocate pro rata based on costs above
Peak-trains	2,436	664	3,100	Peak-trains	
Peak-cars	794	106	900	Peak-cars	
Car-hrs	1,494	185	1,678	Car-hrs	
Car-kms	3,217	427	3,644	Car-kms	
Train-hrs	2,267	154	2,421	Train-hrs	
Train-kms	-	-	-	Train-kms	
Pass-op-hrs	267	68	334	Pass-op-hrs	
OPEX subtotal	**98,221**	**14,549**	**112,770**		

Table 3.3.3 Cost allocation (continued)

Capital Charges (GW)	**33,959**	**1,324**	**35,283**		
Depreciation (accounting)	**15,858**	**582**	**16,440**		
Matangi Units	13,174	-	13,174	Peak-cars	
Wairarapa carriages	-	224	224	Peak-cars	
Stations etc	2,684	358	3,042	Peak-cars	
Capital return (4% of depreciated value)	**18,101**	**742**	**18,843**		
Matangi Units	14,369	-	14,369	Peak-cars	
Wairarapa carriages	-	244	244	Peak-cars	
Stations etc	3,732	498	4,230	Peak-cars	
CAPEX subtotal	**33,959**	**1,324**	**35,283**		
GRAND TOTAL	**132,179**	**15,873**	**148,053**		

Table 3.3.4 then presents a summary of the results of the cost allocation process. Its three sections show:

i) the total costs allocated to each output measure, subdivided between EMU/metro and Wairarapa (WRL) services;
ii) the total annual operating statistics (resource requirements) for each output measure and the metro/Wairarapa split - derived as described in Section 3.2; and
iii) the resultant unit cost rates, by output measure and metro/Wairarapa - derived simply through dividing the allocated costs by the relevant operating statistic.

Table 3.3.4: Cost allocation and unit cost summary

	Resource requirements				Unit cost rates				Cost allocation ($000)		
	Metro	**WRL**	**Combined**	**Units**	**Metro**	**WRL**	**Combined**	**Units**	**Metro**	**WRL**	**Total**
Peak-trains	22	6	28	#	1,095.60	806.6	1,033.70	$000 pa	24,103	4,840	28,943
Peak-cars	132	20	152	#	311.8	126.6	287.4	$000 pa	41,158	2,531	43,689
Car-hrs	269.7	33.3	303	000 pa	52.2	47.7	51.7	$	14,081	1,591	15,671
Car-kms	13,266	1,761	15,028	000 pa	2.3	2.3	2.3	$	30,033	3,988	34,021
Train-hrs	77.4	5.3	82.6	000 pa	259.8	478.4	273.7	$	20,096	2,512	22,608
Train-kms	3,701.00	278.5	3,979.40	000 pa	-	-	-	$	-	-	-
Pass-op-hrs	45.1	11.4	56.5	000 pa	55.3	55.3	55.3	$	2,490	630	3,120
Total									**131,961**	**16,092**	**148,053**

Key points worth noting from Table 3.3.4 include the following:

- Almost half (49%) of the total costs relate to peak trains and peak cars, with the remainder effectively relating to the overall amount of service provided (hours and kilometres). This indicates that: (i) about half the costs are related to the overall size of the operation and the level of assets involved, independent of the extent of their use; and (ii) the remaining half of the costs varies with the extent of use of these assets throughout the day. The clear implication of this is that, at the margin, providing additional services in off-peak periods is very much cheaper than providing additional peak period services.
- In peak periods, provision of a given amount of additional service on the Wairarapa line (subject to the availability of additional locos and carriages) appears to be significantly less costly than provision of the equivalent amount of additional EMU services (the peak train and peak car costs for the Wairarapa service are considerably lower than those for the EMU services, to a considerable extent as a result of the Wairarapa's lower capital

charges). In off-peak periods, the cost relativities are less clear-cut (the Wairarapa train-hour related unit cost is substantially higher than the equivalent EMU unit cost).

Further commentary relevant to the total costs and unit costs results is provided in Section 3.5 of this paper.

3.3.4 Incremental/avoidable cost and allocated cost analyses

Our analysis of the financial performance of the WGN rail services is intended to shed light on differences in performance between (i) the different rail lines; and (ii) within each line, the peak and off-peak periods. As noted in the previous section (3.3.3), almost half the total costs relate to peak trains and peak cars, irrespective of their utilisation. This does not give rise to any particular cost allocation issues when examining performance by line, as all lines have their peak periods at almost the same time and so the number of peak trains and peak cars required on any one line is independent of the requirements of the other lines. However, it does give rise to something of an issue when examining performance by time period (for a given line), as some peak train and peak car costs are incurred jointly across peak and off-peak periods.

For instance, as noted in Section 3.2, the maximum peak car requirement for the whole system (excluding Wairarapa) is 132 cars, while the maximum requirement in the off-peak period reduces to about 30 cars over this period. In cost allocation terms, this means that about 102 cars (77% of the peak requirements and costs) should be attributed solely to the peak period services, while a maximum of about 30 cars (23%) are required jointly between peak and off-peak periods. Given this 'jointness', there is no 'correct' way of allocating these costs between the two periods.

A theoretically correct analysis would therefore allocate 77% of the peak car costs to the peak periods only, leaving 23% joint (unallocated) between the two periods. An incremental or avoidable (or marginal) costing analysis of interpeak services would therefore not include any costs (or cost savings) relating to these 23% joint cars.

However, for assessing performance across time periods (peak vs off-peak), it may be useful to simplify the presentation and interpretation of the results by allocating these joint costs between the two periods concerned in some 'neutral' manner. For our assessment of performance results by line and time period (in Section 3.5), we have therefore 'allocated' the joint period costs (which relate to both 'trains in service' and 'cars in-service') that these trains or cars operate between peak and off-peak periods[38] in proportion to the relative train hours and car hours in each of the two periods[39]. It should be noted that these allocations of joint costs relate to only a minority of the per car and per train costs (see Table 3.2.3 and Figures 3.2.2 A/B and 3.3.4) , as the majority of these car and train resources operate in the peak periods only (and are therefore allocated fully to these periods).

3.4 Data and Analyses -- Patronage and Revenues

The annual aggregate passenger and revenue statistics (2018/19) for Wellington train services are summarised in Table 3.4.1. The patronage data is readily available in the public domain. However, only

[38] The incremental hourly costs are likely to be lower in the off-peak. However, without doing a detailed scheduling analysis (which is too detailed for this case study), we were not able to quantify this effect.

[39] This allocation should be based on the proportions of train hours and car hours in each of the peak and off-peak periods after deducting the train and car hours operated in peak periods by the 'peak only' trains and cars.

aggregate revenue was available. Additional analysis was carried out to estimate and apportion the revenue data between time periods and lines.

Table 3.4.1: WGN Rail Patronage and Revenue Control Totals & IWA Estimates (2018/19)

Item	Peak	Off-peak	Total	Source
Passengers (mill)	9.541	4.783	14.324	Advice GW to IWA
Pax km (mill)	231.524	108.002	339.526	IWA estimates
Revenue – Fares ($mill)	37.5	15.6	53.124	NZTA Key Factor report 2018/19
Revenue – SGC ($mill)	0	2.413	2.413	NZTA Key Factor report 2018/19
Revenue – Total ($mill)	37.5	18.0	55.537	IWA estimates

The results from our apportionment of patronage, passenger km and revenues by line and time period are given in Table 3.4.2, with further description of the apportionment process as follows: (a) Fare revenue was apportioned between period and line using an unweighted least squares regression (see Figures 3.5.1A/B) of distance from Wellington station against adult single 10-trip fare (assuming most trips are to/from Wellington station); (b) The intercept (flag-fall) value was then multiplied by passenger boardings and the slope value by passenger-kms and adjusted to the control totals;[40] (c) Supergold revenue was apportioned to lines in the off-peak period based on the standard fare distribution.

Passenger boardings, passenger-kms and revenues were then further apportioned by line segment. This apportionment was based on an analysis of the GWRC 2017 rail survey reported boarding and alighting counts by station. The 2017 survey counts were used to apportion passenger boardings and passenger-kms to the shortest segment of the line (based on peak operating patterns) that would cater for the stations they were travelling between (it was assumed all trips were to/from Wellington Station). This was done separately for each line and time period (peak/off-peak) and adjusted to the appropriate control totals.

Table 3.4.2: Wellington train patronage and revenue (2018/19)

		Wellington Train 2018/19						
Period	**Line**	**Passenger boardings (million)**	**Passenger-kms (million)**	**Fare revenue ($million)**	**Supergold revenue ($million)**	**Total passenger revenue ($ million)**	**Fare revenue per boarding ($)**	**Passenger revenue per boarding ($)**
Peak	HVL	4.1	73.2	13.7	0.0	13.7	3.32	3.32
	KPL	3.9	106.2	16.4	0.0	16.4	4.22	4.22
	JVL	0.9	7.1	2.2	0.0	2.2	2.40	2.40
	WRL	0.6	45.0	5.2	0.0	5.2	8.38	8.38
Peak subtotal		**9.5**	**231.5**	**37.5**	**0.0**	**37.5**	**3.93**	**3.93**
Offpeak	HVL	1.9	34.2	5.6	0.9	6.4	2.86	3.31
	KPL	2.1	55.8	7.6	1.2	8.8	3.56	4.11
	JVL	0.6	4.3	1.2	0.2	1.3	2.07	2.39
	WRL	0.2	13.7	1.3	0.2	1.5	8.63	9.96
Offpeak subtotal		**4.8**	**108.0**	**15.6**	**2.4**	**18.0**	**3.27**	**3.77**
Total	HVL	6.1	107.4	19.3	0.9	20.1	3.17	3.31
	KPL	6.0	162.0	24.0	1.2	25.1	3.99	4.18
	JVL	1.5	11.5	3.3	0.2	3.5	2.27	2.40

[40] The regression formula derived is: Fare = $2.23 + $0.126 * Kms. This may be regarded as a relatively 'flat' fare structure: passengers can travel for up to 18 km before the fare paid reaches twice the flag-fall rate (of $2.23).

	WRL	0.8	58.6	6.6	0.2	6.8	8.43	8.69
Grand total		**14.3**	**339.5**	**53.1**	**2.4**	**55.5**	**3.71**	**3.88**

Source: GWRC key factor data for passenger boardings and passenger-kms. Waka Kotahi key factor data for fare revenue and Supergold revenue: these were apportioned by period and line based on regression analysis of fare schedule.

3.5 Overall Results and Commentary

3.5.1 Aggregate financial performance – costs, revenues and subsidies

Table 3.5.1 gives an overview of the financial and related performance of the WGN metropolitan rail system in 2018/19, with key points being:

- Total gross costs (including capital charges) were some $148 million.
- The system earnings were $53.1 million from fares revenues and a further $2.4 million as a specific subsidy in compensation for the provision of free travel outside peak periods for 'Supergold card' (SGC) holders.
- The extent of subsidies was therefore $92.5 million as a general subsidy plus the $2.4 million SGC compensation. The corresponding cost recovery proportions were 35.9% excluding the SGC compensation as revenue or 37.5% including this.
- The system carried some 14.3 million passenger 'boardings' with an average travel distance of 23.7 kms.
- The gross costs equated to an average of $10.34 per passenger boarding or $0.44 per passenger km.
- The corresponding net costs (subsidies) including the SGC subsidy payments were $6.63 per passenger ($0.28 per passenger km); or $6.46 per passenger ($0.27 per passenger km) excluding these payments.

Table 3.5.1: WGN rail financial performance overview (2018/19)

Item	Units	Excl SGC revenue	Incl SGC revenue
Gross costs	$mill	148.05	
Passenger boardings	mill	14.32	
Passenger km	mill	339.5	
Ave trip distance	km	23.7	
Fare revenues	$mill	53.12	
Gross cost/passenger	$	10.34	
Gross cost/pax km	$	0.44	
Revenues	$mill	53.12	55.53
Subsidy	$mill	94.93	92.52
Cost recovery	%	35.9%	37.5%
Subsidy/passenger	$	6.63	6.46
Subsidy/pax km	$	0.28	0.27

3.5.2 Financial performance by line and time period

Table 3.5.2 disaggregates the Table 3.5.1 figures to show the system's financial and related performance broken down by time period (peak/off-peak) and between the four lines. Points of particular note include:

- The two 'main' lines (i.e. from the Kapiti Coast and the Hutt Valley) account for 85% of the system total passenger boardings (12.1 million out of the total 14.3 million), and 79% of the total passenger kms.
- The peak period services account for 68% of the system total passenger kms and for 59% of the system total costs (on our allocated cost basis). Resulting from this, the system per passenger and

per passenger km subsidy rates are significantly higher in the off-peak than in the peak period: the per passenger subsidy averages $9.28 in off-peak periods and $5.30 in peak periods[41].

- Consistent with the above, the overall cost recovery is significantly higher in the peaks (at 43%) than in the off-peak periods (26%, or 30% if the SGC payments are counted as a fare substitute).
- Examining results by the four lines, the overall cost recovery (excluding SGC payments) is highest on the Kapiti line and the Wairarapa line, both at 41%; with the figures for the other lines being 34% for Hutt Valley and 19% for Johnsonville.
- The average trip lengths on the four lines differ widely: the longest is for the Wairarapa line (73.3 km), followed by the Kapiti line (27.0 km), the Hutt Valley line (17.6 km) and the Johnsonville line (7.7 km).
- The subsidy levels per passenger on the different lines are within a reasonably narrow range in the peak period (between $4.90 on the Hutt line and $7.50 on the Wairarapa line); but cover a much wider range in the off-peak period (between $6.80 on the Kapiti line and $31.60 on the Wairarapa line). While the Wairarapa line performs poorly on this measure, its overall subsidy level per passenger km is the lowest of the four lines ($0.16), while the Johnsonville line has the highest subsidy per passenger km ($1.20) by a considerable margin.

Table 3.5.2: Summary of Financial Performance by Line and Time Period[(a)]

Period	Line	Passenger boardings (PAX #m)	Passenger-kms (PAX-KMS #m)	Pass fare revenue (REV_NSGC $m)	SGC fare revenue (REV_SGC $m)	Pass + SGC revenue (REV $m)	Gross cost ($m) pa	Cost recov incl SGC (REV/COST)	Cost recov excl SGC	Subsidy/Pax ($ excl SGC)	Subsidy/Pax km ($ excl SGC)
Peak	HVL	4.1	73.2	13.7	0.0	13.7	34.1	40%	40%	4.92	0.28
	KPL	3.9	106.2	16.4	0.0	16.4	35.7	46%	46%	4.98	0.18
	JVL	0.9	7.1	2.2	0.0	2.2	8.4	26%	26%	6.92	0.88
	WRL	0.6	45.0	5.2	0.0	5.2	9.9	53%	53%	7.45	0.10
Peak subtotal		9.5	231.5	37.5	0.0	37.5	88.0	43%	43%	5.30	0.22
Offpeak	HVL	1.9	34.2	5.6	0.9	6.4	23.0	28%	24%	8.96	0.51
	KPL	2.1	55.8	7.6	1.2	8.8	22.1	40%	34%	6.83	0.26
	JVL	0.6	4.3	1.2	0.2	1.3	8.7	15%	13%	13.60	1.74
	WRL	0.2	13.7	1.3	0.2	1.5	6.2	25%	21%	31.58	0.36
Offpeak subtotal		4.8	108.0	15.6	2.4	18.0	60.0	30%	26%	9.28	0.41
Total	HVL	6.1	107.4	19.3	0.9	20.1	57.0	35%	34%	6.21	0.35
	KPL	6.0	162.0	24.0	1.2	25.1	57.8	43%	41%	5.63	0.21
	JVL	1.5	11.5	3.3	0.2	3.5	17.1	20%	19%	9.46	1.20
	WRL	0.8	58.6	6.6	0.2	6.8	16.1	42%	41%	12.21	0.16
Grand total		14.3	339.5	53.1	2.4	55.5	148.1	38%	36%	6.63	0.28

- ***Note (a): The cost allocations in this Table between peak and off-peak periods are based on a 'neutral 'allocation of joint costs between periods (as outlined in section 3.3.4)***

We also show the performance results pictorially in Figures 3.5.1A and 3.5.1B. Figure 3.5.1A shows costs and revenues per passenger by line, for peak, off-peak and all periods combined. Figure 3.5.1B shows the equivalent information on a per passenger km basis. For the peak period services and the total services, the results have also been disaggregated by line 'segment' (as defined in Table 3.2.2): the Kapiti line is split

[41] Note that these relative peak and off-peak results are based on the assumptions adopted for the allocation of joint period costs, as outlined in section 3.3.4.

into three segments – Porirua, Plimmerton and Waikanae; and the Hutt Valley line is similarly split into three segments – Melling, Taita and Upper Hutt.[42] [43]

Features of these results worthy of comment include the following:

- The fare revenue per passenger versus distance regression function approximates to a straight line, with a flagfall component (for zero distance) of $2.23 and a distance component of $0.126 per kilometre (refer Section 3.4).
- The cost per passenger also increases with distance (unsurprisingly), but with a less regular pattern:
    - the Johnsonville line is clearly an 'outlier', with costs/passenger around 50% higher than indicated by the cost regression line (i.e. taking account of the distance involved)
    - the Kapiti line has a significantly lower cost per passenger than the Hutt Valley line, despite its average trip length being around 50% greater.

[42] The Melling line diverges from the main Hutt Valley line just north of Petone; but a substantial proportion of the users of the Melling line would otherwise use the Hutt Valley line so that, from their perspective, the Melling services may be regarded as a 'short run' of the Hutt Valley services.

[43] Our disaggregation of the performance results by line segment has been undertaken on the assumption that (in peak periods) all passengers would use the shortest service segment that would match their travel (station – station) needs.

Figure 3.5.1A: Costs and revenues per passenger - lines & segments

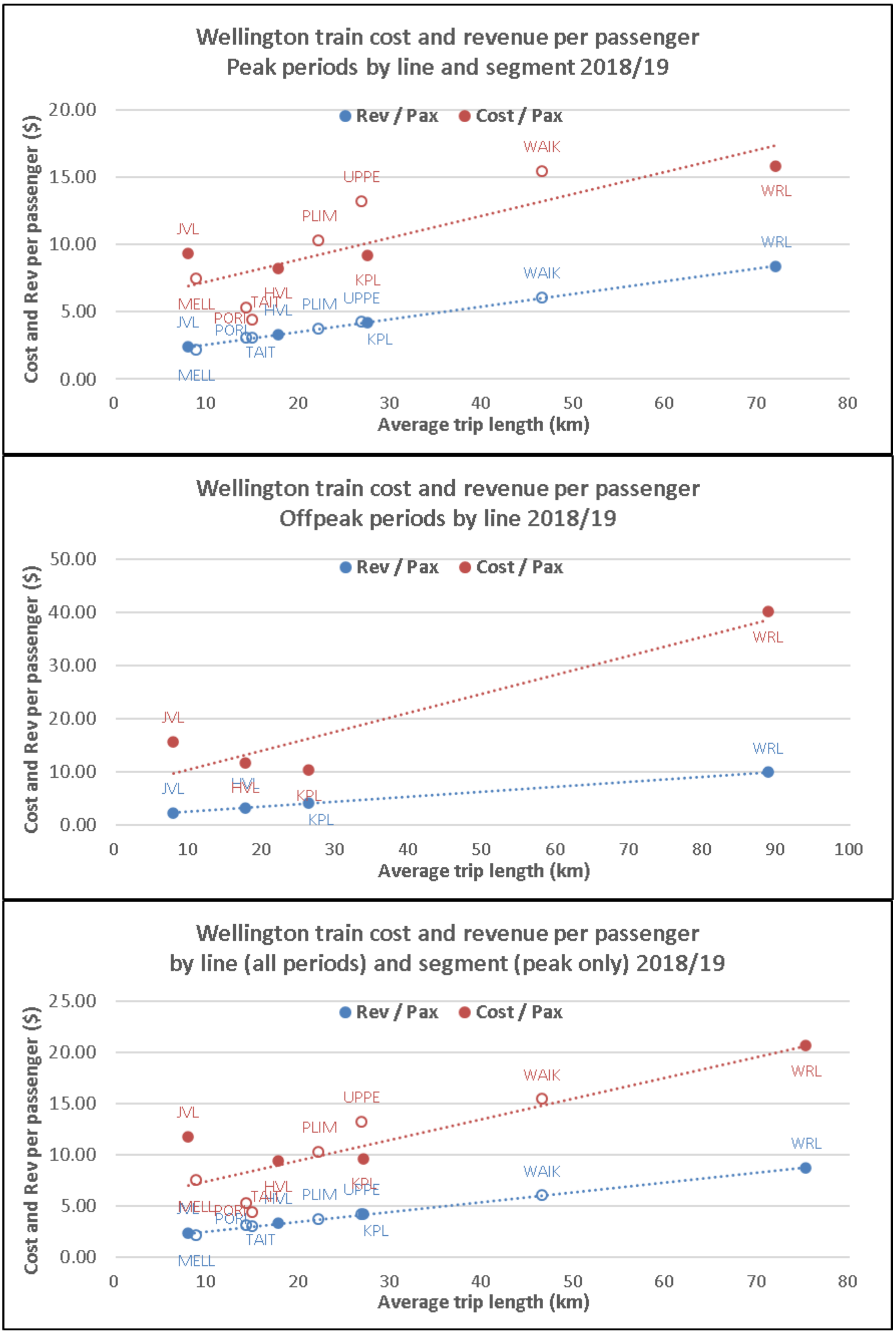
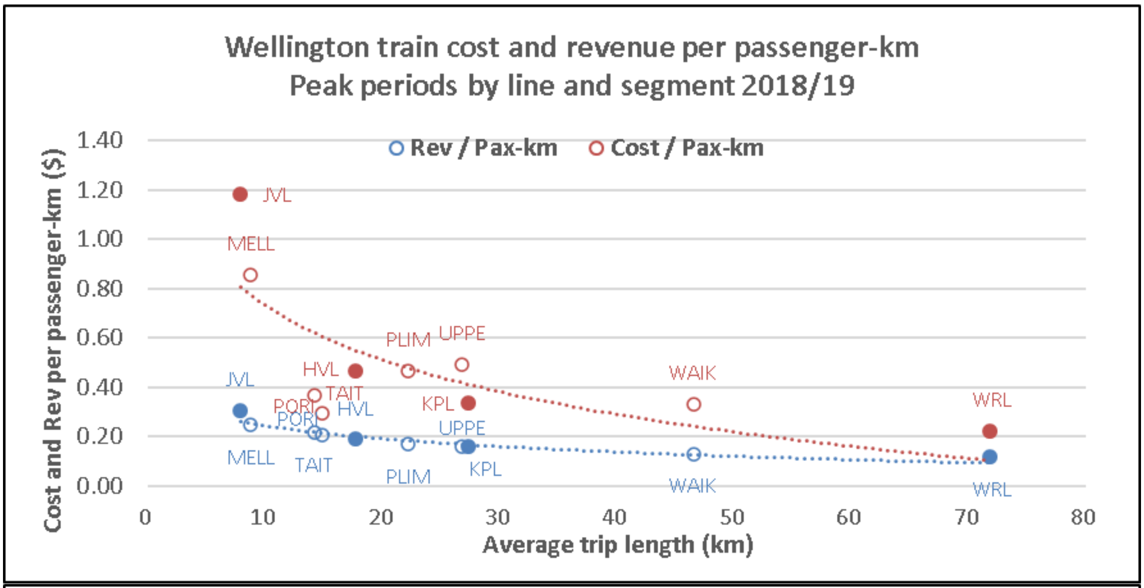
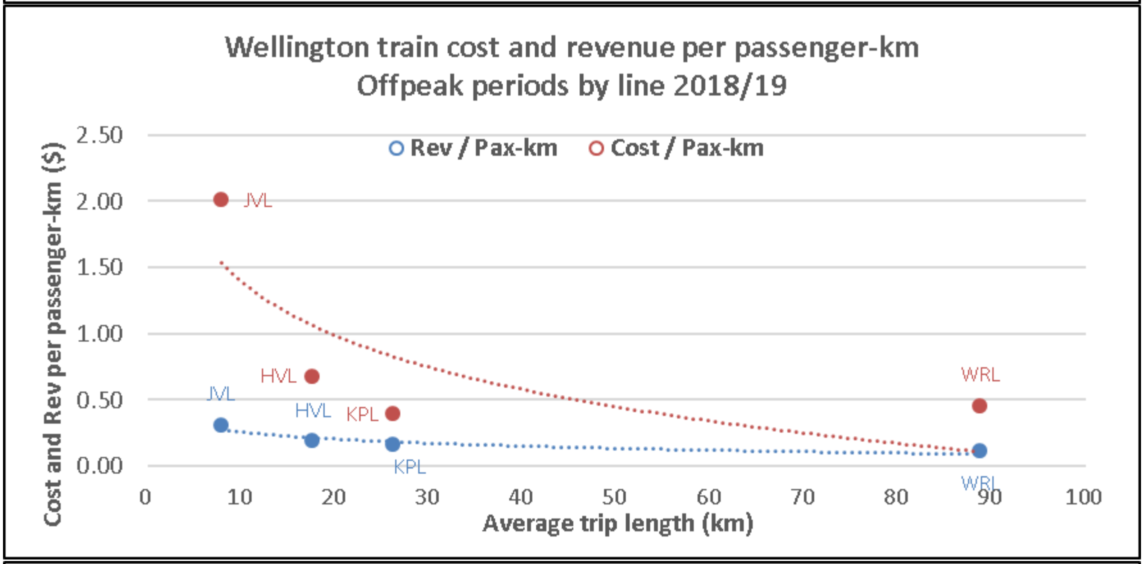
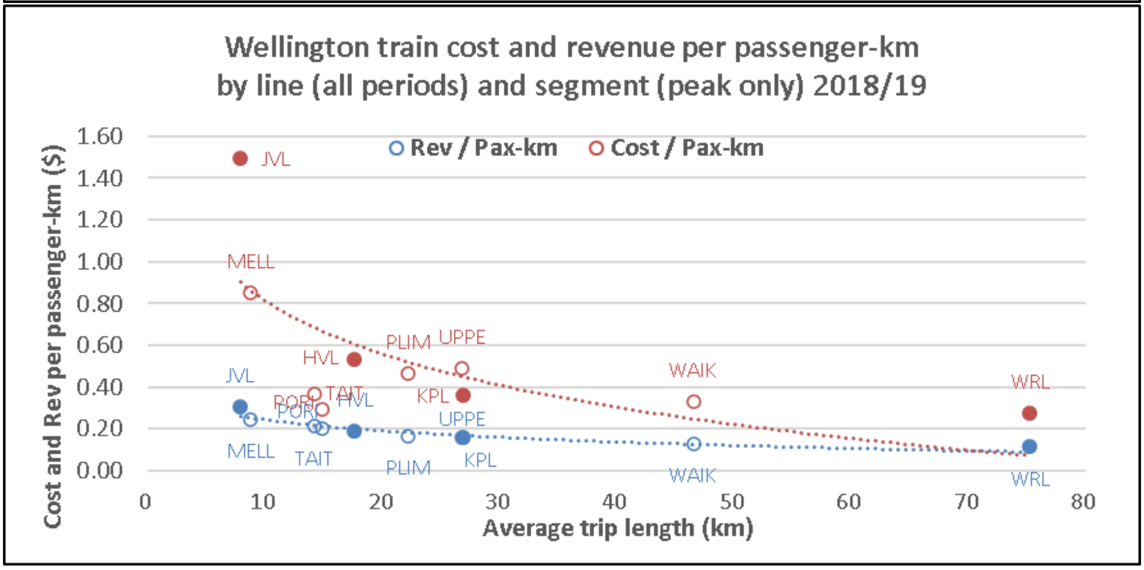


Figure 3.5.1B: Costs and revenues per passenger kilometre - lines & segments







3.5.3 Marginal cost assessment

We examine marginal costs from two perspectives, i.e. (A): A supply-based perspective, which assesses the costs at the margin of increasing service levels, in peak and/or off-peak periods; and (B): A demand-based perspective, which assesses the service level impacts and any related cost impacts of increases (exogenously) in the passenger demand for use of the rail system.

(A). Supply-based perspective

To illustrate this approach, we estimate the gross costs of increasing the service levels on the HV line by 1,000 train hours per year at:

- *Peak periods*. We assume this increase is provided by one additional peak train, operating 4 hours per day (250 weekdays per year) with six cars per train (so 1,000 train hours p.a. and 6,000 car hours p.a. total) and an average operating speed of 50 km/hr (this reflects typical peak period operations on the current HV line).
- *Off-peak periods.* Here we assume the same incremental 1,000 train hours pa, but assume two cars per train (typical of current off-peak operations) and so 2,000 car hours p.a. total.

Table 3.5.3 sets out our indicative costings for these peak and off-peak service increments. In broad terms, the incremental costs are some $4.3 mill p.a. for the peak service, $0.6 mill p.a. for the off-peak service. If we were to increase the off-peak service to provide 6,000 car hours pa, this would triple the cost to about $1.8 mill pa, i.e. still well below half the costs of providing the same amount of service in peak periods. As is evident from the table, this clearly illustrates the considerable cost differences between increasing services at peak periods (where both incremental capital costs and incremental operating costs are large) and comparable increases at off-peak periods (which involve minimal capital costs and considerably lower operating costs).

Table 3.5.3 Marginal cost example: Hutt Valley Line, 1 additional train, 4hr/day, peak vs off-peak periods

			Peak (4 hr/day)		Off -peak (4 hr/day)	
	Variable	**Unit rate**	**Units**	**$000 pa**	**Units**	**$000 pa**
Costs	Peak-trains	1,095.6	1	1095.6	0	0.0
	Peak-cars	311.8	6	1870.8	0	0.0
	Car-hrs	52.2	6,000	313.2	2,000	104.4
	Car-kms	2.3	300,000	679.1	100,000	226.4
	Train-hrs	259.8	1,000	259.8	1,000	259.8
	Pass-op-hrs	55.3	2,000	110.5	0	0.0
	Total pa			4329.1		590.6
Patronage	Pax p.a.		1,000	413.5		234.5
	Pax km pa		17,700			
Fare Rev				1371.0		315.0
Incremental Cost/Pax				10.47		2.52
Incremental Rev/Pax				3.32		1.34

(B). Demand-based perspective

Here we consider the question of the financial impacts of any exogenous increases in demand for the rail services, at peak periods and/or off-peak periods:

- ***Peak periods****.* The current services are (broadly) planned so that they are fully utilised to their effective capacity in the peak period (or certainly within the peak one hour within this period) for travel in the peak direction at their point of maximum loading. The implication is that a (say) 10%

increase in peak period demand would require a 10% increase in peak capacity, which in practice is likely to translate into an approximately 10% increase in total units required and in the number and/or length of trains operated in the peak period.

The incremental costs given in Table 3.5.3 would (broadly) apply in such a case. This shows an incremental cost of around $4.3 mill p.a. for running one additional (6-car) peak train. On the basis that average loadings per peak train were not to change, the corresponding incremental revenues would be around $1.4 mill pa, i.e. around 30% of the incremental costs. On a per incremental passenger basis, the incremental costs are estimated at around $10.50 and the fare revenues at around $3.30.

- ***Off-peak periods****.* In general, ample spare capacity is available on most off-peak services, before the need for any passengers to stand. A 10% increase in demand could therefore be readily accommodated, without any need to increase service levels or to provide longer trains (more cars).

On the basis of the above, we conclude that:

- In ***peak periods***, any substantial increase in demand is likely to require a proportionate increase in service capacity, which would involve both increased capital costs (principally for additional rolling stock) and increased operating costs. The peak period analysis in Table 3.5.3 provides a broad guide to the incremental (marginal) costs likely to be involved in providing additional peak capacity, to the extent that this could be achieved without substantial engineering costs.[44]
- In ***off-peak periods***, there is more than adequate capacity on the present services. In this case, the marginal costs of accommodating additional passengers are close to zero. (There would undoubtedly be some such costs, but these would be trivial relative to the peak period costs: a more detailed appraisal would be necessary if it were required to quantify them.)

[44] The issue of peak period route capacity and potential (engineering-based) solutions to provide increased capacity is discussed briefly in Section 3.4 of this paper; but detailed consideration is outside the scope of DTCC.

Chpater 4 Wellington Bus – costs and charges analysis

4.1 Overview

This chapter makes estimates of the costs of typical NZ urban bus operations, on both average cost and marginal cost bases, for peak and off-peak periods. It is in four main sections, as follows:

- Development of a cost model representative of NZ urban bus operations (section 4.2).
- Application of this model to the WLG region bus operations to derive current allocated costs (per passenger task measure), revenues and financial performance for peak and off-peak periods (section 4.3).
- Estimation of marginal (incremental) **financial** costs applicable to changes in service supply and/or patronage levels for the WLG bus operations (section 4.4).
- Assessment of marginal **economic** costs associated with marginal changes in service supply (service levels) for the WLG bus operations (section 4.5).

We note that most of the analyses in this chapter are based on statistics and estimates for the WLG bus system (2018/19). However (as described further below) our cost estimates are based on a modification of the WLG system costs so as to better reflect more typical cost structures across NZ urban bus operations overall. These cost structures are based more-or-less directly on the bus operator contract costs (prices) which, in most cases, have resulted from competitive tendering with private operators for the right to operate groups of services (generally for periods of 6, 9 or 12 years). The cost structures cover the operations of bus services, including the supply of vehicles, i.e. essentially those cost categories which are covered in the bus operator contracts. They do not cover other 'overhead' costs -- such as GW management functions, passenger information services, ticketing systems and bus system infrastructure (bus stops, shelters, terminals, bus priority measures etc).

4.2 NZ urban bus cost model

This case study developed and applied a cost model typical of NZ urban bus operations in the larger urban centres.[45] Points of note include:

- The model expresses the costs of operating urban bus services in terms of three cost 'drivers': (i) bus hours in operation (directly reflecting public timetables); (ii) bus kilometres run to cover these timetables; and (iii) the maximum number of buses required over a 'normal' day to provide the timetabled operations.
- The model's unit costs also include allowances for non-timetabled hours and kilometres (e.g. for running to/from the depot and switching between routes) and for 'spare' buses to cover for bus breakdowns, maintenance requirements etc.
- The cost model also includes allowances for: (i) a 'normal' profit margin (or management fee) relating to provision of the services by a private operator; and (ii) an annualised capital charge covering the costs of bus ownership (generally consistent with the costs that would be involved for the operator under a finance lease arrangement).
- The resultant unit costs (Table 4.2.1) are as experienced by a typical bus operator. These very largely reflect resource costs. Two cost components - road user charges and bus licensing fees - may be regarded as non-resource components: these account for only a small proportion (less than 10%) of total operating costs.[46]

[45] The model developed is a refinement and update of the 'generic' bus operating cost model originally developed by IWA and outlined in MBCM section 4.4 – Evaluation of Public Transport Service Activities.

[46] NZ bus owners/operators pay road user charges (RUC), bus licence fees etc on the same (or very similar) basis to the comparable charges on owners/operators of trucks with similar mass, configuration, payload rating etc.

The model's unit cost values in Table 4.2.1 have been selected as representative of cost rates (in early/mid 2019) applying to competitively-tendered contracts in the main NZ centres. These rates were established through an open tendering process in or around 2018 in each of the centres. : this process resulted in relatively similar cost rates across tendered contracts in all regions. However, substantial proportions of the bus service contracts in both AKL and WLG were subject to a negotiation process with incumbent operators rather than competitive tendering. These negotiated contracts in both the centres have significantly higher cost rates than the rates for tendered contracts in these and the other main regions (Wallis, 2020)[47].

For a typical urban bus running 50,000 kms p.a. of timetabled services at an average speed of 22 km/hr (equating to 2,270 timetabled hours pa), the total (financial) costs would be approximately $250,000 p.a. Of this total, some 45.2% varies with the total time of operation (i.e. relates to bus hours and principally bus driver costs), 33.6% varies with distance (i.e. relates to bus kilometres and principally fuel, bus repairs and maintenance, road user charges), 17.6% relates to bus capital charges and the remaining 3.7% relates to bus operating overheads. This $250,000 figure may also be expressed as an average cost of approximately $5.00 per service km or $110 per service hour.

[47] 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

Table 4.2.1: NZ Urban Bus Operations Cost Model

	All costs at Mar 19 quarter prices (excl GST)					
Unit cost category	**Cost driver**	**Cost items**	**Unit cost rates**			**Notes**
			$/Bus hr	**$/Bus km**	**$Pk Bus pa**	
A. Op costs - time	Bus hrs	Driver - wages & direct on-costs	32.00			
B . Op costs - distance	Bus kms	Fuel (diesel)		0.44		Consumption rate 40l/100km (price $1.10/l (excl GST)
		Oil, lubricants		0.04		
		Tyres and tubes		0.05		
		Bus R&M - wages, parts, materials, external services		0.30		
		Road user charges (Note 1)		0.293		
C. Op costs - vehicles	Buses	Bus rego, licensing, comp insurance			1,250	
		Bus cleaning, fuelling			2,000	
		Depot rent & rates			3,500	
Sub-total above			32.00	1.12	6,750	
D. Op costs - overheads	% mark-up on items A-C	Overheads labour, other, minor asset charges	15%	15%	15%	
Sub-total op costs			**36.80**	**1.29**	**7,763**	
E. Profit margin	% mark-up on items A-D	Profit margin/ management fee	7%	7%	7%	
F. Bus capital charges (Note 2)	Buses - by new price, age	Ave cap charge pa, covering depreciation & interest			39,510	
Total all above costs			**39.38**	**1.38**	**47,816**	
Factors to cover out-of-service operations (Note 3)			1.25	1.20	1.10	
Unit rates per service hr, service km, pk bus etc			**49.22**	**1.66**	**52,598**	

Note (1):
* RUC rates for buses from Oct 2018 were $0.263 (<18,000 kg) and $0.323 (>18,000 kg), excl. GST: we use the average of these.

Note (2):
*Based on new bus cost $450k, retained for 18 years, sale value 10% of original price, finance lease (PMT) @ 5% real interest rate with equal monthly payments over 18 years.

Note (3):
* Bus hr factor: Allows for additional driver time for out-of-service running, terminus time etc additional to TT time.
* Bus km factor: Allows for 20% out-of-service km additional to TT kms.
* Peak bus factor: Allows for 10% 'spare' buses in fleet additional the minimum number required to provide the daily TT services.

4.3 Financial assessment (Wellington bus) - average costs and charges

The bus costing model[48] set out in Table 4.2.1 has been applied to statistics for the Wellington bus operations (2018/19 prices, based on typical NZ bus operating costs) to assess financial performance, both in aggregate and divided between peak and off-peak periods, in terms of: (i) market and revenue statistics (bus boardings, passenger kilometres, fare revenues); (ii) operational statistics on the extent of services provided (bus kilometres, bus hours, peak buses); (iii) cost allocation and unit cost rates; and (iv) overall financial performance (including subsidy and cost recovery levels).

This appraisal has focused on the Wellington region services only, as:

- It is the second largest urban bus operation in NZ (although only about half the size of the Auckland bus operation).
- It has the highest rate of bus usage (bus journeys pa/population) of all NZ urban areas.
- it has the best data readily available for our analyses, particularly in terms of the split of operating statistics, patronage and fare revenues between peak and off-peak periods.
- The comparative analyses we have undertaken recently for other projects indicate that the WLG and AKL bus operations and markets generally have very similar performance ratios, including in terms of their splits of operational and market statistics between peak and off-peak periods. For similar bus types, the unit costs in the various regions are within quite a narrow range; but the total cost (e.g. per bus km) may differ considerably between regions, particularly because of differences in average operating speeds.

We therefore expect that the pattern of results described below for WLG (especially in terms of the peak vs off-peak performance differences) is likely to be applicable in broad terms to the bus operations in the other main centres. However, we would caution that our results should be treated as approximate rather than precise in their reflection of the WLG situation, as we have had to base some of our input figures (particularly on the costing side) on estimates derived from previous IWA studies rather than WLG-specific 2018/19 figures.

Table 4.3.1 sets out our Wellington analyses. Key features are as follows:

General:

** All data provided is on an annual basis, reflecting the 2018/19 financial year.

** Total figures have been broken down between peak and off-peak periods: peak periods refer to services starting before 0900 and between 1500 and 1830 on weekdays; all other services are off-peak[49].

Market statistics (rows 1--82):

** *Fare revenues.* Total fare revenues for the year were $46.5 million (excl GST), equating to an average of $1.88 per boarding or 28.6 c per passenger kilometre. About 10% of this ‘fare’ revenue relates to central government reimbursements to the regional councils as a ‘fare substitute’ in compensation for the provision of free travel (in off-peak periods) under the NZ SuperGold scheme.

Operational statistics (rows 9, 109):

***Size of operation.* The WLG bus services operated some 14.7 million in-service km and some 600,000 in-service hours in the year[50].

[48] For the purpose of the analysis, the cost model was calibrated for a 45-seat diesel, single-deck bus, which is a good approximation to the great majority of the buses then operating in WLG.

[49] This peak/off-peak split by time periods is consistent with that used for the eligibility for Supergold passes (in off-peak periods only); and also with the availability of discounted ticket prices for other PT users.

[50] These figures imply an average operating speed (terminus – terminus) of 24.2 km/hr. this is rather higher than most other estimates of bus operating speeds in the Wellington region, suggesting that most likely the service hour estimate is understated.

** *Bus requirements (rows 11, 12).* The services are provided by 390 'peak buses' on normal weekdays[51]. This indicates an average distance operated per peak bus of about 38,000 km per year, which is relatively low for urban bus operations in major NZ centres (and reflects the relatively low average speed of the WLG services).

** *Average bus loadings (row 13)*. The ratio passenger km/service km represents the (distance-weighted) average numbers of passengers on a bus, averaged over the length of the bus route, over all routes and over all time periods. The average figure for the WLG services is 11.0 passenger km/service km (comprising 11.9 in peak periods, 10.1 in off-peak periods): these figures are high relative to other NZ urban bus operations, and occur despite many of the most highly utilised public transport services in the region being operated by urban rail services, not by buses.

Cost allocation and average costs (rows 14 – 208):

** Unit cost rates. The unit cost rates used here are taken directly from Table 4.2.1. They approximate to the level of cost payments to bus operators resulting from the competitive tendering of contracts in 2018/19. [52]

** Main cost components. Our cost model splits the costs into three main components, in descending order of size: (i) service hr related costs (approximately 40% of total) - mainly relates to bus driver wages and direct driver on-costs; (ii) service km related costs (33% of total) - main items are fuel, bus repairs and maintenance, and road user charges; and (iii) vehicle- related costs (27% of total) - main item is capital charges associated with bus ownership (depreciation and interest or leasing payments, depending on the operator's financing model) and a proportion of company overheads related to the size of the bus operation.

** Cost allocation – peak/off-peak periods. Using the chosen unit cost rates (from Table 4.2.1), Table 4.3.1 provides an allocation of the costs for the WLG bus operation between peak and off-peak services. The resulting aggregate cost rates for the two periods are then shown as averages per bus hour (row 18) , per bus kilometre (row 19) and per peak bus (row 20). These figures indicate that, expressed on a per bus hour basis, the off-peak cost rate is 18% below the peak rate; on a per km basis, it is 22% below the peak rate, and on a per bus basis is 85% above the peak rate. In our view, the relative bus hour and bus km costs give the best guide to the overall cost relativities between peak and off-peak periods for providing a given amount of service, i.e. the off-peak cost is around 20% lower than the peak cost. [53]

[51] in addition to these 'peak buses', operators typically have an additional 10% (approximately) 'spare' buses to cover for breakdowns, maintenance requirements etc.

[52] As noted earlier, these unit cost rates will understate the average cost rates paid for bus services in the Wellington region, as they do not take account of the generally higher cost rates paid for negotiated contracts. They also do not attempt to take any account of GW's administrative costs for service planning, ticketing systems, real-time information and other functions not covered by operator contracts.

[53] These per bus km and bus hr relative cost figures may be derived relatively easily (as reflected in rows 21-23), as these costs vary directly with the number of bus km and bus hrs in the two periods. The allocation of the per bus costs between periods is more debatable, as a large proportion of the fleet are used in both peak and off-peak periods (so the costs are not readily separable). For the proportion of the total fleet that are used in both periods, our analysis has divided the relevant costs in proportion to the number of bus hours that these vehicles operate in each period (this is similar to the approach taken for the WLG rail analyses – refer chapter 3). The next section of this paper, on marginal costs, looks at the implications of alternative assumptions on allocating such 'joint' costs.

Table 4.3.1 WLG Bus Statistics and Cost Allocations 2018/19

	Item	Units	Total	Peak	Off-peak	Off-pk/Pk ratio	O/pk %	Notes and Sources
1	Boardings	000	**24,747**	**13,200**	**11,547**	0.87	47%	GW Patronage Statistics
2	Pax kms	000	**162,355**	84,626	77,729	0.92	48%	GW Patronage Statistics
3	Ave trip length	kms	6.56	6.41	6.73	1.05		Calc from above
4	Fare revenues	$000 excl GST	**42,198**	24,239	17,959			GW advice
5	SGC revenues	$000 excl GST	**4,305**	-	4,305			GW advice
6	Tot revenues	$000 excl GST	46,503	24,239	22,264	0.92	48%	Calc from above
7	Ave tot rev/pax km	$	0.29	0.29	0.29	1.00		O/pk: pk ratios: assume 1.000 (incl SGC reimbursement)
8	Ave tot rev/boarding	$	1.88	1.84	1.93	1.05		O/p: pk ratios: assume 1.05 for WLG Bus (as for trip length) [AKL 1.205, CAN 1.048, WAI 1.020]
9	Service km	000 pa	**14,741**	7,085	7,656		52%	ECan BCB (N272) GW estimates for totals (km, hr, PVR) Assume ave pax km/serv km o/pk = 0.85 propn of pk value (IWA)
10	Service hr	000	**609**	300	308		51%	Assume pk km/hr = 0.95 * off-pk km/hr (IWA)
11	Max buses in service	#	**390**	390	76		45%	Off-pk: pk ratio IWA estimate
12	PVR allocated		**390**	**268**	**122**		31%	**Calcs given in note below**
13	Pax km/Serv km	#	11.01	11.94	10.15			Calc from above
	Cost allocation:	Unit rate		$000pa				Unit cost rates from Table C1.
14	Service km	**1.66**	**24,469**	11,761	12,709			Costs derived from unit cost rates * operating stats above
15	Service hr	**49.22**	**29,950**	14,779	15,171			
16	Vehicles (allocated)	**52,598**	**20,513**	14,096	6,418			
17	Total		**74,933**	**40,635**	**34,298**	74,933		
	Average costs:							
18	$/hr		123.14	135.33	111.27	0.82		Total costs (by period) divided by operating stats (by period)
19	$/km		5.08	5.74	4.48	0.78		
20	$/veh (allocated)		192,136	151,632	281,097	1.85		
	Cost recovery (incl SGC reimb with fare revenues):							This section treats SuperGold payments ('fare substitutes') as a component of fare revenues.
21	Total subsidy	$000	28,430	16,396	12,034	0.73		
22	Tot rev: Tot costs	%	0.62	0.60	0.65	1.09		
23	Subsidy/Boarding	$	1.15	1.24	1.04	0.84		
24	Subsidy/Pax km	$	0.18	0.19	0.15	0.80		
	Cost recovery (excl SGC reimb from fare revenues):							This Section A5xcludes SuperGold payments from fare revenues (ie they are treated as part of general subsidies).
25	Total subsidy	$000	32,735	16,396	16,339	1.00		
26	Tot rev: Tot costs	%	56%	60%	52%	88%		
27	Subsidy/Boarding	$	1.32	1.24	1.41	1.14		
28	Subsidy/Pax km	$	0.20	0.19	0.21	1.08		

Note:- Allocation of 'all day' (joint) bus costs between time periods

Peak period:	Tot service hrs	300,262	Off-peak period:	Tot service hrs	308,238
	# buses	390		# buses	175.5
	Days pa	250		Days pa	250
	Ser hrs/day/bus	3.08		Ser hrs/day/bus	7.03
Allocn of all-day bus costs (pro rata to bus hrs):					
	Propn jt hrs to pk	30.5%			
	Propn jt hrs to o/pk	69.5%			
	Jt buses to pk	53.49			
	Jt buses to o/pk	122.01			
	Equiv buses-pk	267.99			
	Equiv buses-o/pk	122.01			
	% PVR cost to pk	68.7%			
	% PVR cost to off-pk	31.3%			

Overall financial performance (rows 21-28) :

** The first sub-section here (rows 21-24) provides analyses of cost recovery and subsidies on the basis that Supergold reimbursements are treated as part of fare revenues (a 'fare substitute') and are therefore excluded from the subsidy figures. The second sub-section (rows 25-28) takes the opposite view, excluding Supergold reimbursements from fare revenues and therefore including them as part of the overall subsidy figures.

** Cost recovery (revenue/cost ratio)(rows 21-24). Including Supergold reimbursement as a revenue component, the overall cost recovery was estimated at 62% (or 56% excluding this component). The breakdown of this 62% figure by time period was 60% in the peak period, 65% in the off-peak (or 52% off-peak excluding the Supergold revenue reimbursement).

** Subsidy levels (rows 21, 25). The total annual subsidy was $28.4 million (increasing to $32.7 million including the Supergold reimbursement amount as part of the subsidy). Based on the above allocation of joint peak/off-peak costs, $16.4 million of this amount was attributed to the peak period services and $12.0 million to the off-peak services (increasing to $16.3 million including the Supergold component).

** Subsidy ratios (rows 23/27, 24/28). Overall, the average subsidy per boarding (rows 23, 27) was $1.15 (increasing to $1.32 if including the Supergold reimbursement as part of the subsidy). By the two time periods, the peak subsidy/boarding was $1.24 and the off-peak rate was $1.04 (but increasing to $1.41 if including the Supergold reimbursement as part of the subsidy). The pattern of these results for the average subsidy per passenger km (rows 24, 28) is somewhat similar: including the Supergold reimbursement payments in the revenue figures shows a lower off-peak subsidy/passenger km (15.5c) than the peak subsidy (19.4c); but excluding this reimbursement results in a higher off-peak subsidy/passenger km rate (21.0c).

4.4 Financial assessment (Wellington bus) -- marginal costs and charges

Marginal costs were assessed from two main perspectives:

- ***4.4.1: A supply-based perspective***, which assesses the gross cost impacts at the margin of increasing (or decreasing) bus service levels, in peak and/or off-peak periods.
- ***4.4.2: A demand-based perspective***, which 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 (e.g. resulting from fuel price changes).

4.4.1 Supply-based perspective

To illustrate this approach, the gross costs of varying the levels of bus service supply were estimated for the following situations:

- A1: Off-peak (weekday) periods only
- A2: Peak periods only -- based on a marginal bus providing services for 3 hours per day over the two peak periods (which is typical of the 3 hours average/peak bus provided by the existing services)
- A3: 'All day' period -- based on a marginal bus providing 3 hours/day peak period services and 7 hours/day off-peak services (i.e. essentially the sum of A1 plus A2).

This assessment uses the unit operating costs derived in Table 4.2.1 and reproduced in Table 4.4.1 (rows 15-17) i.e. $49.22/service hr + $1.66/service km + $52,598 p.a./peak bus.[54]

[54] Note that our methodology assumes that all bus operating costs are directly variable with one of three measures of output (service hours, service kms, peak vehicles required-PVR), i.e. the marginal costs of service supply are equal to the average costs of supply (on a per bus hr, bus km

Table 4.4.1 summarises the results of applying these unit costs to the three marginal operating scenarios:

- On a per service hour basis (row 29), the off-peak only services have the lowest incremental costs $89/hr, with the peak-only services having the highest costs ($160/hr) and the all-day services lying between these two ($110/hr).
- On an annual cost basis (row 31), based on incremental services on 250 weekdays), the peak costs (3 service hours/day) are the lowest at $120,000 p.a., followed by the off-peak only costs (7 service hours/day) at $157,000 p.a. and then followed by the all-day costs (10 service hours/day) at $276,000 p.a.

and PVR basis). This is considered to be a reasonable assumption in the medium term for the NZ bus sector, which is periodically opened to competition (competitive tendering) 'for the market': it is consistent with the widely-held view (by transport economists and others) that "there are no significant economies or diseconomies of scale in the urban bus sector".

Table 4.4.1. WLG Bus Marginal Costing Analyses

	Item	Units	Total	Peak	Off-peak	Off-pk: Pk ratio	O/pk %	Notes and Sources
1	Boardings	000	24,747	13,200	11,547	0.87	46.7%	GW Patronage Statistics
2	Pax kms	000	162,355	84,626	77,729	0.92	47.9%	GW Patronage Statistics
3	Ave trip length	kms	6.56	6.41	6.73	1.05		Calc from above
4	Fare revenues	$000 excl GST	42,198	24,239	17,959			GW advice
5	SGC revenues	$000 excl GST	4,305	-	4,305			GW advice
6	Tot revenues	$000 excl GST	46,503	24,239	22,264	0.92	47.9%	Calc from above
7	Ave rev/pass km	$	0.29	0.29	0.29	1.00		O/pk: pk ratios: assume 1.000 (incl SGC reimbursement)
8	Ave rev/boarding	$	1.88	1.84	1.93	1.05		O/p: pk ratios: assume 1.05 for WLG Bus (as for trip length)
								[AKL 1.205, CAN 1.048, WAI 1.020]
9	Service km	000 pa	14,741	7,085	7,656		51.9%	ECan BCB (N272) GW estimates for totals (km, hr, PVR)
								Assume ave pax km/serv km o/pk = 0.85 propn of pk value (IWA)
10	Service hr	000	609	300	308		50.7%	Assume pk km/hr = 0.95 * off-pk km/hr (IWA)
11	Max buses in service	#	390	390	175.5		45.0%	Off-pk: pk ratio IWA estimate
12	PVR allocated		390	89.43	626.03		160.5%	Calcs given in note below
13	Pax km/Serv km	#	11.01	11.94	10.15			Calc from above
14	Boardings/Serv hr	#	40.67	43.96	37.46			Calc from above
	Cost allocation:	Unit rate		$000pa				Unit cost rates from Table C1.
15	Service km	1.66	24,469	11,761	12,709			Costs derived from unit cost rates * operating stats above
16	Service hr	49.22	29,950	14,779	15,171			
17	Vehicles (allocated)	52,598	20,513	4,704	32,928			
18	Total		74,933	31,244	60,808	92,052		
	Marginal Op Costs/Serv hr:			Per Serv hr	Per Serv km			
19	** Per serv hr			49.22	2.03			
20	** Per serv km * ave km/hr			40.21	1.66			
21	** Per PVR (off-peak only)			0	0.00			
22	** Per PVR/250/10 (all day)			21.04	0.87			
23	** Per PVR/250/3 (peak only)			70.13	2.90			
24	Tot per serv hr: off-pk only			89.43	3.69			
25	Tot per serv hr: all day (10hrs)			110.47	4.56			
26	Tot per serv hr: peak only (3.0hrs)			159.56	6.59			
	Marginal Op Costs summary:							
27	Description		**Off-peak only**	**Peak only**	**All day**			
28	Hours/day	Hours	7	3	10			
29	Marg cost/service hr	$/hour (ave)	89.43	159.56	110.47			
30	Marg cost/day	$/day	626	479	1105			
31	Marg cost/year (250 weekdays)	$000/year	156.5	119.7	276.2			

4.4.2 Demand-based perspective

This part of the assessment is concerned with the expected service level and financial impacts to the authority (GW) in response to a change in demand (assumed at both peak and off-peak periods) resulting from some exogenous factor (such as fuel price changes). For illustrative purposes, we assume a 10% exogenous increase in demand (but noting that our analysis would be symmetrical for a corresponding decrease in demand).

The way in which such a change in demand feeds through to changes in service levels, operating costs and fare revenues is detailed in Table 4.4.2, and the methodology and results are summarised as follows:

- For the purpose of the analysis, it was assumed that the 10% demand increase would result in increases in service levels by the authority to maintain the current maximum loading standards, during peak services. On this basis, our best (but indicative) assessment is that the authority's initial response to this demand increase would be to increase peak period service frequencies by around 8% and off-peak service frequencies by around 3%. These estimated increases are on the basis that most (but not all) peak period/peak direction services are currently loaded to close to their planned capacity at their maximum load point; but that most (but not all) off-peak services currently have spare capacity.
- These increased frequencies would themselves encourage increased patronage (endogenously) by reducing bus waiting times and improving service convenience: our estimate is that this ('second-round') effect would increase patronage by around a further 2%[55].
- To accommodate these additional passengers there would need to be a further ('second-round') increase in service frequencies, resulting in total frequency increases of around 9.5% in peak periods, 3.5% in off-peak periods.
- The marginal (incremental) costs resulting from these increased services are estimated at about $5.6 million p.a., which is an increase of some 7.5% on the current total annual costs for the region's bus services.
- The incremental revenues resulting from the 12% overall increase in patronage would be about $5.5 million p.a. (i.e. 12% addition to current fare revenues) - indicating that the incremental cost recovery would be almost 100%, i.e. there would be minimal change in total subsidy requirements.
- Notably, the analyses indicate an ***increase*** in subsidy to peak period services of around $1.7 million pa; but a ***reduction*** in subsidy for the off-peak services of $1.6 million pa. This result largely reflects that, in broad terms, most additional passengers at off-peak periods can be accommodated within the existing service capacity; whereas most additional peak period passengers would require additional capacity to be provided, including the expansion of the total bus fleet.

[55] This estimate of a 2% patronage increase resulting from service increases of 8% peak and 3% off-peak is consistent with service frequencies elasticities of about 0.25 peak and 0.66 off-peak. These service elasticities are based closely on previous NZ/Australian evidence on the demand effects of urban bus service increases in a range of time periods [reference: Wallis I P (2013) 'Experience with the development of off-peak bus services'. NZTA research report 487].

Table 4.4.2. WLG Bus Financial Impacts of Exogenous Demand Changes 2018/19

	Item	Units	Total	Peak	Off-peak	Notes and Sources
	Service level elasticities:					
1	Demand elast (SR) wrt service hours		0.45	0.30	0.60	MBCM Tables 82, 83(off-pk c 2* peak)
2	Elast adjustment for reduced ave speeds		-10%	-10%	-10%	Assumed impact of reduced speeds as result of increased loading/unloading times
3	Adjusted elast wrt service hours		0.41	0.27	0.54	Estimated adjusted elast
	Demand impacts:					
4	Demand changes (+10% exogenous)		10.0%	10.0%	10.0%	Assumed exogenous pax increase
5	Service level increase factor (exog)			8.0%	3.0%	Service increase to accommodate exog increase in demand Table 4.5.1.
6	Resultant addl demand			2.2%	1.6%	
7	Total demand increase			12.2%	11.6%	
8	Adjusted service level increase			9.7%	3.5%	Pro rata to demand increase in each period
	Revenue impacts:					
9	Total base revenue	$000pa	46,503	24,239	22,264	From Table 4.4.1, row 6 (incl SGC revenue)
10	Revenue increase	$000pa	5,535	2,947	2,587	
	Cost impacts:					
11	Base marg costs/service hr	$		159.56	89.43	From Table 4.4.1, row 24-26
12	Total sevice hrs pa	000 serv hrs	608.5	300.3	308.2	From Table 4.4.1, row 10
13	Incr in service hrs pa	000 serv hrs	40.0	29.2	10.7	Row 8 * row 12
14	Tot marg costs for service incr	$000pa	**5,622**	**4,661**	**961**	Row 11 * row 13
	Marginal financial performance:					
15	Net cost increase	$000pa	87	1,713	- 1,626	Row 14 - row 10
16	Cost recovery (marginal)	%	98%	63%	269%	Row 10 / row 14

4.5 Economic assessment (Wellington bus) -- marginal costs and charges

The previous section (4.4) addressed the financial cost to the operator associated with marginal increases in patronage: these results were an example of '***operator (financial) economies of scale'***, with the (gross) marginal financial costs to the operator being less than the average costs of service supply; and with the net marginal costs (i.e. marginal costs - marginal revenues) being close to zero.[56]

This section focuses on the marginal **economic** costs[57] associated with the marginal user, i.e. any increase in (gross) operator costs less any economic benefits (travel time etc) to existing passengers resulting from any increase in service levels to accommodate the marginal passenger: these are ***'user economies of scale'.***

Appendix A sets out the theory behind this user economies of scale assessment (this is known as the 'Mohring effect' in the context of urban public transport services). It shows that, subject to specified assumptions, the benefits to existing passengers (in aggregate) of increased service levels (resulting in reduced waiting times) are equal to: (i) that part of the waiting time function related to headway; times (ii) the value of the waiting time savings.

Mathematically, these frequency benefits to existing users associated with additional passengers may be expressed as:

User benefits = (b * h) * VTTS * Es, where:

b= variable waiting time vs headway factor

h = initial headway

VTTS = standard value of passenger[58] (in-vehicle) time savings (on as behavioural basis)

Es = ratio % change in service frequency: % change in patronage (service: patronage 'elasticity', as shown in Table 4.5.1).

Table 4.5.1 presents calculations for a typical range of the various parameter values for urban bus services in peak and off-peak periods. A wide range of values is evident, with the values varying in direct proportion to (i) initial headway, (ii) service: patronage 'elasticity', (iii) waiting time: headway factor; and (iv) behavioural values of user time savings.

For typical **peak** period bus services (with service: patronage 'elasticity' values [59]around 0.8), the benefit values to existing users (in aggregate) are around $0.90 to $1.40 per incremental (marginal) passenger. For typical **off-peak** bus services ('elasticity' values around 0.3), these user benefit values (in aggregate) are in the range around $0.20 to $0.40 per incremental passenger.

[56] The net marginal costs were close to zero in the example given, but with substantial cross-subsidy (for the marginal change) from off peak to peak periods.

[57] The term marginal economic costs refers here to the marginal change in passenger (generalised) time relating to changes in user waiting times.

[58] Different values of time for standing and sitting passengers (based on Waka Kotahi's MBCM values) can be applied, where relevant and appropriate.

[59] Refer Appendix A.2 for further information on this aspect.

These benefit values are 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. [60]

[60] 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.

Table 4.5.1. User Economies of Scale (Marginal Cost) Examples – Bus services

Time period	Initial headway min	Service: patronage 'elasticity'	Wait time (IV mins): headway factor	Value of IV Time c/min	Ex user Benefit per Incr Pax $
	(h)	(Es)	(b)	(VTTS)	(UB)
Peak	10	0.7	0.82	13.3	0.76
	10	0.8	0.82	13.3	0.87
	10	0.9	0.82	13.3	0.97
	20	0.7	0.67	13.3	1.25
	20	0.8	0.67	13.3	1.42
	20	0.9	0.67	13.3	1.60
Off-peak	10	0.2	0.82	7.8	0.13
	10	0.3	0.82	7.8	0.19
	10	0.4	0.82	7.8	0.26
	20	0.2	0.67	7.8	0.21
	20	0.3	0.67	7.8	0.31
	20	0.4	0.67	7.8	0.42
	30	0.2	0.55	7.8	0.26
	30	0.3	0.55	7.8	0.39
	30	0.4	0.55	7.8	0.52

UB = b*h*VTTS* Es (c)

Value of time estimates (IVT values)

(Behavioural values) -PT User (July 2002 rates)

	Commuter (Peak)	Other (Off-pk)		MBCM Table 14
Seated	$4.70	$3.05		
Standing	$6.60	$4.25		
% standing	25%	0%		IWA estimate
Wtd ave valu	$5.18	$3.05	2002$	
			1.54	Factor Jly 02 - Jly 19
Ave/hr -$	$7.97	$4.70	2019$	
Ave/min - c	13.3	7.8		

Wait time (IVT mins) vs Headway factor

Headway (mins)	WT:H'way Factor SI funct	W+D fn	Ave factor
10	0.83	0.80	0.815
20	0.65	0.69	0.670
30	0.52	0.58	0.550

Source: ATAP Guidelines: M1 Public Transport - PT Parameter Values Public consultation draft, Nov 2020 (Fig 15)

[NB: These factors include allowance for wait time values rel to IVT values]

Appendix 1 User Economies of scale (Mohring effect)

Summary

Scope

- This appendix aims to describe the mathematical formulation of user economies of scale in urban public transport, and in particular the Mohring effect (ie. benefits to existing public transport users resulting from increased demand).

Findings

- The user economies of scale effect, of which the Mohring effect is a particular case, is significant and needs to be taken into account in any economic (SRMC) analyses for urban public transport.
- The Mohring effect may be formulated as simple function of headways.
- For NZ-wide analyses and case studies, need to determine likely operational response to increased demand, by region and mode, for train/bus by peak/off-peak.

A1.1 Introduction

This appendix describes the 'Mohring Effect' and outlines the basis for its quantification for urban passenger transport in the context of the study.

The Mohring effect[61] is the user economy of scale effect associated with additional users of public transport: additional passengers typically result in increases in service levels (e.g. frequency) to accommodate them, and these increases provide benefits to existing public transport users. The effect represents a positive externality associated with increased public transport use (by distinction from the negative externality associated with increased car use in congested conditions).

The following sections of this appendix cover:

- Section A2 – outlines the various likely responses to increased patronage
- Section A3 – provides an illustrative example and mathematical analysis of the Mohring benefits
- Section A4 – sets out conclusions on our proposed methodology.

A1.2 Potential Responses to Patronage Increases

If the patronage on a public transport service increases, a number of operational responses are possible:

- The service could stay the same but the average load increase
- 'Banker' services could be operated to carry extra passengers
- Larger vehicles or longer trains could be run
- More services could be provided, operating more frequently
- More services could be provided, covering more routes.

Depending on whether the increase was at a time of peak patronage, interpeak, or spread over the whole day, all or any of the above may occur.

[61] Named after Herbert (Herb) Mohring and published as Mohring H (1972). Optimization and scale economies in urban bus transportation. American Economic Review (591-604).

(1) No change to the service

In this case, there is little or no change in cost to the operator. More passengers could require additional stops and/or longer boarding and alighting times. The main consequence would be a negative impact on existing passengers. Existing passengers may suffer lower probability of getting a seat, and increased probability of being left behind. We could categorise this situation as low marginal cost to the operator and a negative impact on costs to existing users.

(2) ‘Banker’ services

If the increase in patronage is such that the impact on existing passengers is great (e.g. a high probability of being left behind) an operator might ‘bank’ the heaviest services - i.e. put on extra vehicles running at the same time as the service that is over-loaded. If this occurs during a peak period so the extra capacity is otherwise unutilised, the marginal cost could be higher than the average cost. However, if the patronage increase occurs over an extended period but the extra capacity is only needed for a short time the marginal cost may remain less than the average cost.

(3) Larger vehicles

Higher patronage could be accommodated through the operation of larger vehicles. This is likely to reduce the operating cost per passenger with relatively little impact on user costs. There may be some increase in boarding times. As in the previous case, if the extra patronage is for a short period, extra capacity could be expensive. If the patronage increase is over a longer period, then moving to larger vehicles reflects an economy of scale.

(4) More frequent services

If the average load factor is held constant and the frequency of service increases to cater for the additional patronage, the average cost of supply will stay approximately the same. However more frequent services imply a better service for existing passengers. The average user cost, which includes waiting time, reduces.

(5) Better service coverage

As in the case of frequency, if more patronage results in proportionately more services, the average cost of supply will remain approximately constant, but the average user cost will reduce – in this case because the time needed to access the system may be less, or passengers may have less need to transfer to reach their destinations.

The above discussion shows that the reaction to increased patronage can lead to changes in both the average cost of supply and the average cost to users. The net effect will depend on the period over which the increase occurs, and whether the response is optimised in terms of both user and supplier costs. The last two responses, where the response leads to reduced user costs, are now generally referred to as the Mohring effect.

Prior to Mohring’s article, there was a general assumption in the literature that the primary effect of increased patronage was to increase average costs, as the cost at the peak is higher than the average. If the effect on the user was considered, it was often to include a “congestion” effect (as on roads) as travelling conditions were assumed to worsen. Mohring drew attention to the user benefits from the scale of operation. However as can be seen, there is a range of possible responses providing a mix of supplier and user benefits – all of which could be categorised as “economies of scale” – of which the Mohring effect is one extreme where all the benefits accrue to users. At the other end of the scale, it is often assumed that for rail services, the reaction would be to increase train lengths – no Mohring effect, instead there would be a reduction in the average cost of supply. It is also apparent from the above discussion that it *is* possible for the average cost to increase if the increase in patronage is only over a short period at a time of peak utilisation. We assert without proof that if an increase occurs across a period of time, one or more of the above responses will reduce the average cost over that time period.

In most explanations of the Mohring effect, it is assumed that the increase in patronage is uniform. If the service kilometres are increased proportionately, the total scale of operation increases. With bus operations, it is generally assumed that there are no economies of scale in the cost of supply, so the average cost of the current service is unchanged. However the effect of the increase in frequency is to produce a proportionate reduction in the waiting time and thus the generalised cost of travel for existing users reduces.

A1.3 Illustrative Example and Mathematical Formulation

As an example, assume a simple operation between two points 8 km apart, operating at a 12 minute frequency as follows:

Demand/hour = 100 in each direction
Average load = 100/(60/12) = 20/trip
Operation cost = $3.00/bus km
Travel time = 16 minutes
Fare = 120c

Then if the time walking to and from the stops is 5 minutes, the value of travel time savings is 10c/minute , and we apply the usual weight[62] of 2.0 to access time, a passenger would perceive a total generalised cost of

120 + ((5+12/2)*2 + 16) * 10 = 500 cents

Now assume the demand increases to 120 per hour and the operator increases the frequency so that the average load stays the same. The headway reduces to 10 minutes. The generalised cost per passenger reduces to

120 + ((5+10/2)*2 + 16) * 10 = 480 cents

The generalised cost saving of 20c per passenger trip has been created by adding 20 new passengers thus equating to 1c/additional passenger. It is enjoyed by all 100 existing passengers, so the benefit (ignoring benefits to new passengers) is $1 per additional passenger.

It can be shown that, as long as it is assumed that the headway changes in proportion to the demand and that the waiting time is a linear function of the headway[63], the benefit to passengers is always equal to that part of the waiting time that is related to the headway times the value of waiting time savings. In other words, the marginal user cost is the average user cost minus the variable component of the waiting time.

Mathematically this can be shown as follows:

Social cost = operating cost + user cost

[62] For details, see Waka Kotahi's Monetised Benefits and Costs Manual.

[63] I.e. can be approximated by a + b * h:(in the above example we assumed a=0 and b=0.5).

If we assume the operating cost is proportional to patronage (C = c*Q), headway is inversely proportional to patronage (H = h/Q), and waiting time is a linear function of headway (w=a+b*h), then:
Social cost(S) = c*Q + (walk time*walk weight + travel time + w*waiting time weight)*value of time*Q,
i.e. S= {c + (walk time*walk weight + travel time) * value of time + a} * Q + b *h* wait time weight
So marginal social cost dS/dQ = c + (walk time*walk weight + travel time + a) * value of time.
This is the average user cost without the headway term.

A1.4 Conclusions

The marginal social cost of additional public transport passengers is equal to the average user cost less the Mohring effect term (=b* headway * vtts), where b = the proportion of wait time to headway (typically in the range 0.2 to 0.5).

In the above example, the Mohring term is $1.00, and the MSC (= the optimum fare) is $1.20 - $1.00 = $0.20.

This analysis assumes that the operational response to increased demand is through a pro-rata increase in frequency: it provides an upper bound on the MSC. Other operational responses would be possible and may reduce the marginal user costs below this value.

The total marginal social costs[64] associated with additional passengers would, in general, comprise:

- Marginal operator cost – as derived from operator cost functions
- Marginal user cost - derived as above.

(Marginal externality costs may also apply).

The calculation of marginal operator costs and marginal user costs will depend on the operational response to increased demand:

- In a typical peak situation (where services are demand-driven), a demand increase (say 10%) will typically result in a pro rata (or close to pro rata) service increase, giving an increase in operator costs. In the case of bus services, frequency will increase, giving a reduction in user costs. In the case of train services, similarly, frequency may be increased and hence user costs reduced; alternatively, longer trains may be operated, with a lesser increase in operator costs but no reduction in user costs.
- In a typical off-peak situation, if spare capacity exists, then both marginal operator costs and marginal user costs will be zero. If insufficient spare capacity exists, then the peak analysis (above) would apply.

[64] Where appropriate, bus cost model users may also include public infrastructure costs (such as bus lanes and share of the costs of the road network). However, such costs are not applicable for marginal changes in bus services frequencies.

Appendix 2 "Total mobility" services

The NZ Total Mobility (TM) scheme assists eligible people with long term impairments to access appropriate transport to meet their daily needs and enhance their community participation. This assistance is provided in the form of subsidised doo-to-door transport services wherever scheme transport providers operate. The Total Mobility scheme is intended to compliment the provision of public transport services, which are expected to be as accessible as possible to meet different mobility needs.[65]

The TM scheme is funded in partnership by local and central governments. The scheme is managed and operated by regional councils, with services provided under contract to regional councils by taxi operators in regular or modified mobility vehicles. Scheme users are issued with an electronic card or a book of vouchers from the relevant regional council. Total Mobility subsidies can be claimed anywhere in New Zealand where the scheme operates. The subsidy per trip is 50% of the fare, up to a maximum subsidy level. This maximum subsidy varies between regions.

The total annual subsidy for the TM scheme is some $13 million pa, which is about 1.4% of the total subsidy to regular PT services discussed in the earlier sections. Given this, our examination here of the costs and charges aspects of the TM scheme is somewhat cursory: it focuses on assembling key annual statistics on the TM scheme performance, costs, subsidies etc; and includes in this appraisal some comparisons between the TM scheme costs and the costs for 'regular' PT services.

Table A2.1 provides summary data and performance statistics for 2018/19 for both the TM scheme and the 'regular' local PT services managed by the regional councils (which are the subject of the earlier parts of this paper). Some notable points include the following:

- Some 80,000 people are registered TM users, which represents 1.6% of the total NZ population.
- The registered users made, on average, 22.5 TM trips per year, which may be compared with the average NZ population trip rate on the RC services of 34.5 trips per year. (Note that a substantial proportion of the NZ population never or very rarely uses 'regular' PT services; whereas it can reasonably be assumed that the great majority of people registered in the TM scheme do use it in practice).
- The gross costs (2018/19) of the TM scheme were $29.8 million pa, which was some 2.3% of the gross costs of the RC PT services ($1.306 billion pa). On a per trip basis, the TM gross costs/trip were $16.40 as compared with the 'regular' PT service costs of $7.70.
- The fares paid by the TM users totalled $16.9 million pa, with an average fare per trip of $9.30, an average subsidy of $7.10 per trip and a cost recovery ratio on the services of 57%. By comparison, the users of the 'regular' PT services paid an average fare of $2.10 (per boarding), the average subsidy was $5.60 per trip and the resultant cost recovery ratio was 27%. We note that no data was readily available on the distances of trips made by TM users, so no comparisons of costs, fares and subsidy levels on a per kilometre basis between the two sectors were possible.

We have not attempted any appraisal of the ***marginal costs*** for use of the TM services. However, given that these services are largely provided by taxi operators, operating in a competitive environment, it would appear that the marginal costs associated with any change in levels of demand would be generally similar to the current average costs (i.e.

[65] Refer NZTA (2018): Total Mobility Scheme policy guide for local authorities.

there would be no substantial economies or diseconomies associated with marginal changes in demand for TM services, whether in peak or off-peak periods).

Table A2.1: Key Total Mobility performance statistics and comparisons with regular (RC) PT statistics

		Total Mobility Scheme		Local public transport (RC services)		Ratio TM:PT (%)
Measure	**Units**		**Notes**		**Notes**	
Data inputs:						
Potential users	**# people ('000) registered**	**80.9**		**4920**	**NZ total popn @ 30 June 2019**	**1.6%**
Gross costs	**$mill pa**	**29.8**		**1306**		**2.3%**
Fares paid	**$mill pa**	**16.9**		**358**		**4.7%**
Total trips	**# trips (mill)**	**1.82**		**169.7**		**1.1%**
Ave trip length	km	**n.a.**		**9.36**		**n.a.**
Total trip kms	**# trips * ave km/trip**	**n.a.**		**1588.1**		**n.a.**
Performance ratios:						
Trips/person	#pa	**22.5**		**34.5**		**65%**
Gross costs/trip	$	**16.37**		**7.70**		**213%**
Fares/trip	$	**9.29**		**2.11**		**440%**
(GC-Fares)/Trip	$	**7.09**		**5.59**		**127%**
Fares/Gr costs	%	**56.7%**		**27.4%**		**207%**
Gross costs - Fares	**$mill pa**	**12.9**		**948.0**		**1.4%**
Subsidy/pot. user	$pa	**159.5**		**192.7**		**83%**
Gross cost/trip km	$	**n.a.**		**0.82**		**n.a.**
Fares/trip km	$	**n.a.**		**0.23**		**n.a.**
Subsidy/trip km	$	**n.a.**		**0.60**		**n.a.**

IWA source: 2018_19 - Total Mobility New USE2 1706

Appendix 3 Comparative performance summary (2018/19) -Ministry of Education Bus Services and Regional Council Bus Services

A3.1 Introduction

This appendix provides a comparative summary of performance statistics for FY 2018/19 for:

A. School bus transport services contracted/managed by the Ministry of Education (MoE); and
B. Local/urban bus services contracted/managed by the NZ regional councils (RCs).

In the case of the MoE services, our analyses have focused on the main service categories, i.e. Daily Bus services, Technology Bus services and Direct Resourced (DR) services. Two other categories have **not** been included in these comparisons:

- Special Education School Transport Assistance (SESTA) services: these are largely operated by vans and sedans, and therefore not sensibly comparable with other MoE and with RC services (which are almost all operated by medium/large size buses).
- Maori Medium Schools services: while these are funded by MoE, the Ministry does not hold relevant statistical details.

In the case of the RC services, our analyses have focused primarily on the services provided in the 10 'smaller' regions (classified in terms of PT patronage levels). We consider that the bus services in these regions are more closely comparable with the MoE services (which largely operate in more rural areas) than the RC services in the three large NZ centres (Auckland, Wellington, Christchurch). However, we also provide some comparisons between the MoE bus services and **all** RC bus services (including those in the larger centres).

It needs to be recognised that there are major differences between the characteristics of the MoE bus operations and those of the RCs, including the following:

- The MoE services are strongly 'peaked', in the sense that a substantial proportion of contracted buses are required for only two trips per day (i.e. an AM trip to carry children to school and a PM trip to carry them home). Also, they are required for only (approximately) 190 days per year.
- The MoE services tend to operate at considerably higher average speeds than the RC services. They run mainly on rural roads and are required to stop at relatively few points (which are known in advance).
- The MoE services carry passengers in only one direction. This, together with their peaked nature, results in the ratio of total distance operated to passenger-carrying distance being much greater than for the RC services -- which tends to result in significantly higher costs per service km than is the case for the RC services.

MoE does not hold data on two aspects of its operators' operations which would be highly useful for any performance comparisons:

(i). The total kilometres run by the operator to provide the contracted service. MoE does not, in general, have knowledge of operator depot locations (or locations where buses are kept overnight and between their AM and PM trips), so the total bus kilometres run (or the ratio of total kilometres to service kilometres) cannot be estimated with any accuracy; only professional guesses can be made.

(ii). While MoE has records of passenger trips made (or, at least, of the vehicle capacity specified for each contracted service), it does not hold systematic records of passenger boarding and alighting points. Therefore, it is not possible to estimate total passenger kilometres carried (or average trip distances of passengers) with any accuracy: again, only professional guesses can be made.

Given the above factors, we are of the view that:

1) Even with perfect information (e.g. on total bus kilometres operated and passenger kilometres carried), the very different nature of the MoE and RC bus operations limits the extent to which comparisons between the two sectors would be meaningful.
2) For analyses of comparative cost efficiency etc across the two sectors, the limitations of the data available for the MoE services are such that detailed comparisons are fraught with potential uncertainty.

The comparisons given in the following text and the accompanying tables should be considered in this light.

It is also relevant to note that consideration of the MoE bus services was outside the DTCC's defined scope of work: the school bus services are contracted/managed and funded through the Government's Education vote rather than the Transport vote, and they are therefore not usually regarded as an integral part of the NZ transport system. However, the assessment of comparative performance across the two types of services (which, to the best of our knowledge, has not been undertaken in any systematic way previously) was seen as of significant interest and potentially of value, perhaps particularly to MoE.

A3.2 Comparative Assessment and Key Findings

Our comparative assessment of the two sectors is set out in Table C1, with additional details of the MoE statistics that have been used in this assessment being given in Table C2. The RC bus data in Table C1 is drawn from chapter 2 of this working paper (and its supporting spreadsheets).

The following should be noted:

- The MoE data covers Daily Bus services, Direct Resourced (DR) services and Technology Bus services (with data for the latter being incomplete).
- Data for the MoE SESTA services is included in Table C2 where available, but has not been used in the comparative analyses (Table C1), as most of the services are provided by vans and sedans rather than buses.
- The RC data is given as totals/averages for bus services in: (i) all regions; and (ii) medium size/other regions only. The latter covers 10 regions, i.e. all regions apart from the 'big 3' (Auckland, Wellington, Canterbury). These medium/other regions are considered to provide a better basis for comparison with the MoE services; but they account for only between about 12% and 20% (depending on what statistics are under discussion) of the national totals for all RC bus services.

The main findings from our comparative assessment (for FY 18/19) are provided in the right-hand column of Table C1 and summarised as follows.

Market data (rows 1-3)

- MoE services (excluding SESTA and MMS) carried c28.0 million passenger trips pa, for an estimated 380 million passenger km (average passenger trip length 14.1 km).
- In comparison, RC services in the 10 medium/other regions carried about half (14.5 million) the MoE number of passengers and about 30% of the MoE passenger km (average passenger trip length 8.1 km).

Operations data (rows 4-6)

- The MoE services operated 22.8 million in-service km, which was almost identical to the figure for the RC services in the medium/other regions (22.9 million in-service km).
- As the MoE services involve a much higher proportion of dead running than the RC services, the total bus km estimated for the MoE services (47.0 mill bus km) is considerably higher than the figure for the RC medium/other regions services (26.3 mill bus km).

Cost data (row 7)

- Total (gross) costs for the MoE services were $147.5 million. The corresponding total costs for the RC 10 medium/other regions were $106.3 million (and about $865 million for all RC bus services).

Market performance ratios (rows 8-10)

- The overall passenger trips/service km ratio for the MoE services (average 1.0) is considerably greater than the average for the RC medium/other regions (0.63).
- However, given the longer average passenger trip lengths for the MoE services, the passenger km/service km ratio for the services (14.0) is considerably higher than the figure for the RC medium/other regions (5.1). These ratios represent the average passenger loading over all in-service travel.
- When allowance is made for dead running, the ratio passenger km/total bus km reduces to 8.2 average for the MoE services, 4.4 average for the RC medium/other regions.

Cost: service ratios (rows 11-12)

- The average cost/in-service km for the MoE services was $5.30, some 14% higher than the corresponding cost for the RC medium/other regions of $4.64 average.
- The average cost/total bus km for the MoE services was $3.14, some 22% less than the corresponding cost for the RC medium/other regions of $4.04 average. This difference in relative rates from the cost/in-service km reflects the much higher dead running proportion for the MoE services.

Cost: market ratios (rows 13-14)

- On a cost per passenger trip basis, the MoE average figure of $5.26 was 32% less than the average for the RC medium/other regions of $7.73.
- On a per passenger km basis, the difference is more pronounced: the MoE average figure of $0.38 (Daily and DR services only) is only 42% of (i.e. 58% less than) the average for the RC medium/other regions of $0.91.

A3.3 Conclusions

Given the major differences in the operational patterns and requirements between the MoE bus services and the RC bus (medium/other region) services, it is not possible to draw any conclusions on the relative cost efficiency of the two sectors.

However, we note that all MoE bus services and almost all RC bus services in the ‘medium’ and ‘other’ regions have been procured through competitive tendering processes, which have mostly resulted in significant levels of competition for the service contracts[66,67]. Given these processes, we would expect the contract prices for the services in both sectors to approximate to efficient costs representative of the NZ bus industry[68]. Therefore, we consider that the procurement processes involved in the two sectors are unlikely to be a significant factor in explaining any cost differences between the sectors.

[66] This comment does not apply to the RC bus services in the three large regions, where a substantial proportion of service contracts were determined through a negotiation process with incumbent operators, with the resultant cost (price) rates being generally higher than for their competitively tendered services.

[67] The MoE services are currently in the middle of a new procurement (competitive tendering) round, with the new contracts to commence from the start of the 2022 school year.

[68] We also note that a substantial proportion of the MoE services are provided by the same operators that operate a large proportion of the RC bus services.

	Table C1: Comparative Performance Summary (2018/19): Ministry of Education Bus Services and Regional Council Bus Services								
			MoEd bus data (1)		Source	Regional Council bus data (4)			
	Item	Units	Amount	Notes	Tab C2	Amount M/S regions (5)	All regions	Notes (T C2)	Some comparisons with RC bus services (medium/other regions and national bus figures)
	Aggregate Measures:								
	Market data:								
1	*Total person trips	mill trips	28.050		*27*	14.5	126.0	*27*	***Total passenger trips pa:*** MoE total (28.05 mill) may be compared with the national total for RC bus services of 126 mill, of which 14.5 mill were in the 10 medium/other regions (ie all regions excl AKL, WLG, CAN).
2	*Total person kms	mill km	380.098	Daily + DR only	*28*	117.4	890		***Passenger km pa:*** MoE total (380.1 mill for Daily and DR services) may be compared with the RC bus estimate for the 10 medium/other regions of 117 mill (890 mill for bus services in all regions).
3	*Ave person trip length	km	14.08	Daily + DR only	*13*	8.1	**7.1**		***Ave passenger trip length:*** MoE average (14.1 km) is significantly longer than for RC bus services, which average 8.1 km for the 10 medium/other regions (range 5 to 11 km in most regions).
	****Operations data:***								
4	*Service km	mill km	27.792		*21*	22.9	115.8	*21*	***Service km pa*** : MoE total (27.8 mill) may be compared with 22.9 mill km for RC bus services in the 10 medium/other regions (116 mill for RC bus services in all regions).
5	*Total bus km	mill km	47.014		*23*	26.3	133.2	*23*	***Total bus km pa*** : MoE estimated total (47.0 mill) may be compared with estimated RC bus total in the 10 medium/other regions of approx 26.3 mill (133 mill for all regions).
6	*Ave route length	km	35.09	Daily + DR only	*11*	n.a	n.a		***Ave route length*** : MoE routes are (on average) much longer than the great majority of RC bus routes.
	Cost data:								
7	* Total (gross) costs	$mill	147.459		*31*	106.3	865.3	*31*	***Total (gross) costs pa*** : MoE total ($147.5 mill) may be compared with $106 mill for RC bus services in the 10 medium/other regions and $865 mill for all RC bus services.
	Performance Ratios:								
	Market ratios:								
8	*Person trips/service km		1.01		*29*	0.63	1.09	*29*	***Pass boardings/service km*** (average boarding rate): The average MoE bus rate (1.01) is significantly greater than the average rate for RC bus services in the medium/other regions (0.63) and close to the average for all RC bus services (1.09).
9	*Person km/service km		14.01	Daily + DR only	*28/21*	5.1 ave (range 4 to 9)	7.7 ave	*30*	***Pass km/service km*** (average load): MoE figures (c14 average) are considerably higher than RC bus figures for the 10 medium/other regions, which average 5.1 (range 4 - 9 in each region) and average 7.7 across all regions.
10	*Person km/total bus km		8.24	Daily + DR only	*28/23*	4.4 ave	6.7 ave		***Pass km/total bus km*** : MoE figure (8.2 ave) still considerably higher than RC average for medium/other regions (4.4 ave) and for all regions (6.7 ave).
	Cost ratios:								
11	*Ave cost/service km	$	5.31		*32*	4.64 ave (range 4.20 to 6.20)	7.47 ave		***Ave costs/service km:*** MoE Daily and Tech costs/service km (average $5.31) are on the high side of the comparable costs for RC bus services: for medium and other regions these average $4.64 (range by region $4.20 - $6.20). These higher MoE costs largely reflect its higher proportion of non-service running.
12	*Ave cost/total bus km	$	3.14		*34*	4.04 ave (range 3.30 to 5.20)	6.50 ave		***Average cost/total bus km*** : The MoE costs average $3.14/tot km. The RC costs for the 10 medium/other regions are significantly higher, averaging $4.04 (range by region $3.30 to $5.20).
13	*Ave cost/person trip	$	5.26		*33*	7.33 ave (7.43 med, 6.69 other)	6.87 ave		***Ave gross cost/passenge trip:*** MoE figures (average $5.26) significantly lower than RC services - which average $7.33 in medium/other regions and $6.87 for all RC bus services.
14	*Ave cost/person km	$	0.38	Daily + DR only	*35*	0.91 ave (0.95 med, 0.68 other)	0.97 ave		***Average cost/passenger km*** : MoE figures (Daily, DR services) average $0.38, which is very much lower than for RC services, which average $0.91 for medium/other regions and $0.97 for all RC bus services. These results reflect particularly the much longer person trip lengths by users of the MoE services.

Notes:

Grey shading on table rows indicates estimates that are particularly uncertain.

(1) Table **excludes** data for SESTA services (use smaller vehicles) and Maori Medium Schools (which MoE funds, but does not hold the relevant statistical data). In 2018/19, these involved costs of $45.728 mill (SESTA) and $8.898 (mill MMS), resulting in total costs for all five service categories of $202.086 mill. Further details for SESTA services are given in Table C2.

(2) MoE advised that this information is not kept in any comprehensive form. However its analysis of services in one area (Gisborne, which may well not be typical) gives an average ratio of about 40%. In the absence of any other information, we have adopted this figure (factor 0.4) as an average for all service categories except Tech Bus (for which we have assumed 100%).

(3) MoE advised that this information is not kept or able to be estimated (in general, it does not know the location of the relevant operator depot). It commented that the dead running could be anywhere between 50% and 90% additional to the live running. On this basis, we have assumed an average of 70% (factor 1.7), except for Tech Bus, where we have assumed an average of 35% (factor 1.35).

(4) Data for RC bus services is drawn from Chapter 2 of this paper (and IWA supporting spreadsheets). Figures for total bus km have been estimated by increasing the chpter 2 service km figures by 1.15 to allow for non-service ('dead') running.

(5) The 4 'medium' regions (with higher passenger numbers) are OTA, WAI, BOP, HOR; the 6 'other' regions (with fewer passengers) are NEL, NTL, TAR, HWK, STH, GIS. The remaining ('large') regions are Auckand, Wellington and Canterbury.

	Item		Units	Daily Bus	Technology Bus	Direct Resourced	Sub-total (Daily, Tech, Dir Res)	Special Ed School Transport Assistance	Total All	Source	Some comparisons with RC bus services (national figures, medium & smaller centres)
	Table C2: Ministry of Education Transport Services (2018/19): Annual Summary Statistics by Service Category (1)										
				Service category							
1	# routes			1455	629	558	***2,642***	1300	*3,942*	Input MoE	
2	# vehicles required/route			1	1+ ?	1???		1?		Input MoE?	
3	# daily (1 way) trips/vehicle			2	MoE?	2		2?		Input MoE?	
4	Service days pa	Days pa		192	192?	192	***192***	192		Input MoE?	
5	Vehicle type			Bus -M/L	Bus -S/M/L	Bus -M/L		Van/TMV, sedan			
6	Ave route length	Calc	km	30.68	n.a	46.60	***35.09***	n.a		Input MoE?	***Ave route length*** : MoE routes are (on average) much longer than the great majority of RC bus routes.
7	Ave (student: route) distance	IN		0.4	n.a	0.4		0.4		Refer note (2) below.	
8	Ave student trip length	Calc	km	12.27	n.a	18.64				R6*R7	***Ave passenger trip length:*** Significantly longer than for RC bus services, which are generally in the range 7-11 km for the medium/smaller centres.
9	Service km/day	Bus		89,280	n.a	52,008				Input MoE?	
10		Van/TMV		---	n.a	---		42,738		Input MoE?	
11		Sedan		---	n.a	---		20,385		Input MoE?	
12		All		89,280		52,008		63,123		SUM (R9*R11)	
13	Service km/year	Bus	mill	17.14	0.66	9.99	***27.79***	0.00	*27.79*	R4*R9	
14		Van/TMV	mill	---	---	---	***0.00***	8.21	*8.21*	Input MoE	
15		Sedan	mill	---	---	---	***0.00***	3.91	*3.91*	Input MoE	
16		All	mill	17.14	0.66	9.99	**27.79**	12.12	39.91	SUM(R13:R15)	***Service km pa*** : MoE total (39.9 mill) may be compared with 22.9 mill km for RC bus services in the medium/smaller urban centres.
17	Dead run km factor	Estimate		1.7	1.35	1.7		1.7		Refer note (3) below.	
18	Total bus km	Per year	mill	29.1	0.9	17.0	***47.0***	20.6	*67.6*	R16*17	***Total bus km pa*** : MoE estimated total (67.6 mill) may be compared with estimated RC bus total in the medium/smaller centres of approx 27.0 mill.
19	Students/trip	IN		34.65	31.85	35.68		3.10		Input MoE	
20	Students/day	IN						4,016		Input MoE	
21	Student trips/day	Calc		100,832	n.a	39,819		8,032		R1*R3*R19	
22	Student trips pa	Calc/Given	mill	19.36	1.05	7.65	***28.05***	1.54	*29.59*	R4*R21	***Total passenger trips pa:*** MoE total (29.6 mill) may be compared with the national total for RC bus services of 126 mill, of which 14.6 mill were in the 10 medium/smaller centres (ie all centres excl AKL, WLG, CAN).
23	Student kms pa	Calc	mill	237.6		142.5				R8*R22	***Passenger km pa:*** MoE total (380 mill for Daily and DR services) may be compared with the RC bus estimate for the 10 medium/smaller centres of 118 mill.
24	Student trips/service km	Calc		1.13	1.57	0.77	***1.01***	0.13	*0.74*	R22/R16	***Pass boardings/service km*** (average boarding rate): The average MoE rate (0.74, or 1.01 excl the SESTA services) is significantly greater than the average rate for RC bus services in the medium/smaller centres (0.64).
25	Student km/service km	Calc		13.86		14.27				R23/R16	***Pass km/service km*** (average load): MoE figures (c14 average) are considerably higher than RC bus figures for medium/smaller urban areas, which are in the range 4 - 9.
26	Annual costs (2018/19)	IN	$mill	104.47	4.59	38.40	***147.46***	45.73	*193.19*	Input MoE	***Total (gross) costs pa*** : MoE total ($193 mill) may be compared with $106 mill for RC bus services in the medium/smaller urban areas.
27	Average cost/service km	Calc	$	6.09	6.90	3.85	***5.31***	3.77	*4.84*	R26/R16	***Ave cost/service km:*** MoE Daily and Tech costs/service km are on the high side of the comparable costs for RC bus services: for both medium and smaller urban centres these are in the range $4.20 - $6.20. These higher MoE costs will largely reflect the higher proportion of non-service running for MoE services.
28	Average cost/student trip	Calc	$	5.40	4.39	5.02	***5.26***	29.65	*6.53*	R26/R22	***Ave gross cost/passenge trip.*** MoE figures (except SESTA) somewhat lower than RC services - which average $7.43 in medium urban areas, $6.69 in smaller urban areas.
29	Average cost/total veh km	Calc	$	3.59	5.11	2.26	**3.14**	2.22	2.86	R26/R18	***Average cost/total bus km*** : The MoE costs average $2.86/tot km, which would increase to over $3.00 excl the SESTA services. The RC costs foir the medium/smaller centre services are on average significantly higher, being in the range $3.30 to $5.20.
30	Average cost/student km	Calc	$	0.44		0.27	**0.38**			R26/R23	***Average cost/passenger km*** : MoE figures (Daily, DR services) lower than for RC services, which average $0.95 for medium urban areas, $0.68 for smaller urban areas.

Notes:

Grey shading on table rows indicates estimates that are particularly uncertain.

(1) Table excludes data for Maori Medium Schools (which MoE funds, but does not hold the relevant statistical data). In 2018/19, these involved a cost of $8.898 mill, resulting in total costs for all five service categories of $202.086 mill.

(2) MoE advised that this information is not kept in any comprehensive form. However its analysis of services in one area (Gisborne, which is probably not typical) gives an average ratio of about 40%. In the absence of any other information, we have adopted this figure (factor 0.4) as an average for all service categories except Tech Bus (for which we have assumed 100%).

(3) MoE advised that this information is not kept or able to be estimated (in general, it does not know the location of the relevant operator depot). It commented that the dead running could be anywhere between 50% and 90% additional to the live running. On this basis, we have assumed an average of 70% (factor 1.7), except for Tech Bus, where we have assumed an average of 35% (factor 1.35).

Appendix 4 Financial Appraisal 2018/19 – 2023/24

A4.1 Overview

All the analyses presented elsewhere in this working paper are focused on the position in a single year, i.e. FY 2018/19. This is consistent with the specification for the agreed approach throughout the DTCC study.

Subsequent to completion of the first draft version of this WP, Waka Kotahi expressed a desire for the work to be extended to cover more than a single year, so as to provide additional information on medium term (prospective) trends in the UPT sector, particularly in relation to capital expenditures. Following discussions with Waka Kotahi and MoT, an extension of the scope of the original work on 'NZ UPT Statistics and Performance' (chapter 2 of this paper) was agreed to cover the 6-year period 2018/19 — 2023/24, based on data from two 3-year NLTPs (i.e. 2018/19 -2020/21 and 2021/22 - 2023/24). In addition, it was agreed that UPT expenditures outside the NLTP framework should also be covered for this period, as these expenditures, principally involving Crown funding, have grown considerably in recent years -- with the largest single current project involved being the Auckland City Rail Link (being funded jointly between Auckland Council and the Crown).

The additional work undertaken is summarised in this appendix. It involved the following main tasks:

- Assembly of a database of all UPT capital and operating expenditures in NZ covering the period 2018/19 — 2023/24, and including data from:
    - NLT P expenditures (past and projected) for this period
    - UPT fare etc revenues over the same period
    - other UPT expenditures over the period, from Crown funding and other sources.
- Analysis of these expenditures and revenues by:
    - financial year
    - region
    - continuous programmes (largely opex) and projects (capex)
    - NLTP work category (as applicable).
- Adjustment of financial figures into constant price terms, expressed in average 2018/19 prices (i.e. the same price base as all other DTCC analyses, including those throughout this paper).
- Summary reporting of results and findings, principally in terms of trends in:
    - opex (relative to 2018/19)
    - capex (relative to 2018/19)
    - user contributions (principally fares)
    - performance measures for the UPT system, focusing on measures of financial cost recovery (revenue: cost ratios).

Our analyses and findings are summarised in this appendix, in two strands:

- Financial trends on an annual basis through the 6-year period, expressed primarily relative to the 2018/19 situation. These are summarised in Section A4.2 following.
- Comparisons of the financial results averaged over the six years with those in the initial year (2018/19) of the period. These are summarised in Section A43.

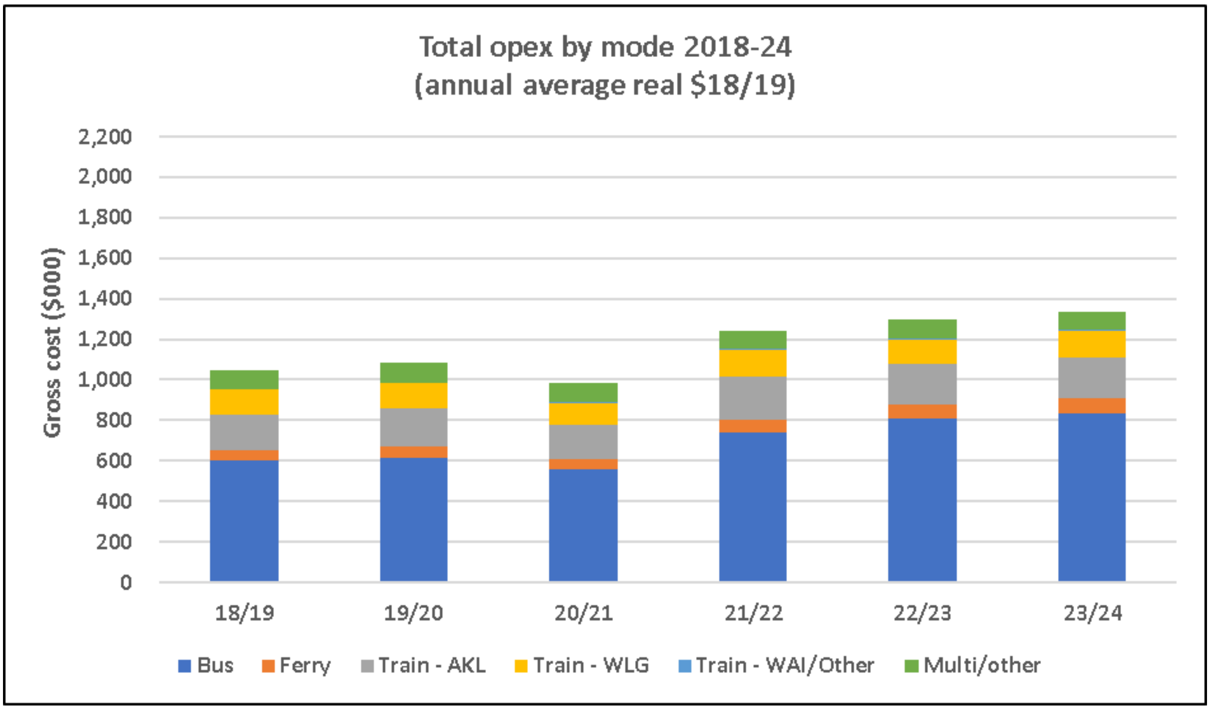
The analyses and reporting in this appendix are provided on a national basis, with (where appropriate) breakdowns by year, by mode and by modal groups (e.g. bus results split between large, medium and smaller regions in patronage terms). Outputs are not provided by individual regions or, in general, by Waka Kotahi work category: much more detailed information is available in the database from which the summary outputs are drawn.

A4.2. Trends by year 2018/19 – 2023/24

A4.2.1 Operating costs

Trends in gross operating costs over the six-year period are summarised in figure DI: these are based almost entirely on NLT P data for the recently -completed 3-year period and the current period (ending June 2024). Total operating costs increase at a modest rate (by around 30% in real terms) over the 6 years, but with all the increase being in the final 3 years: the 2023/24 estimated total is $1,336 million as compared with $1,045 million in 2018/19. By mode, the greatest increase, in both absolute and percentage terms, is for the bus mode, with operating costs increasing in real terms from just under $600 million in 2018/19 to just over $830 million in 2023/24. The train service operating costs (AKL and WGN combined) are forecast to increase by some 11%, to a 2023/24 total of some $330 million.

Figure D1: Total operating costs by mode, 2018-24 ($18/19)



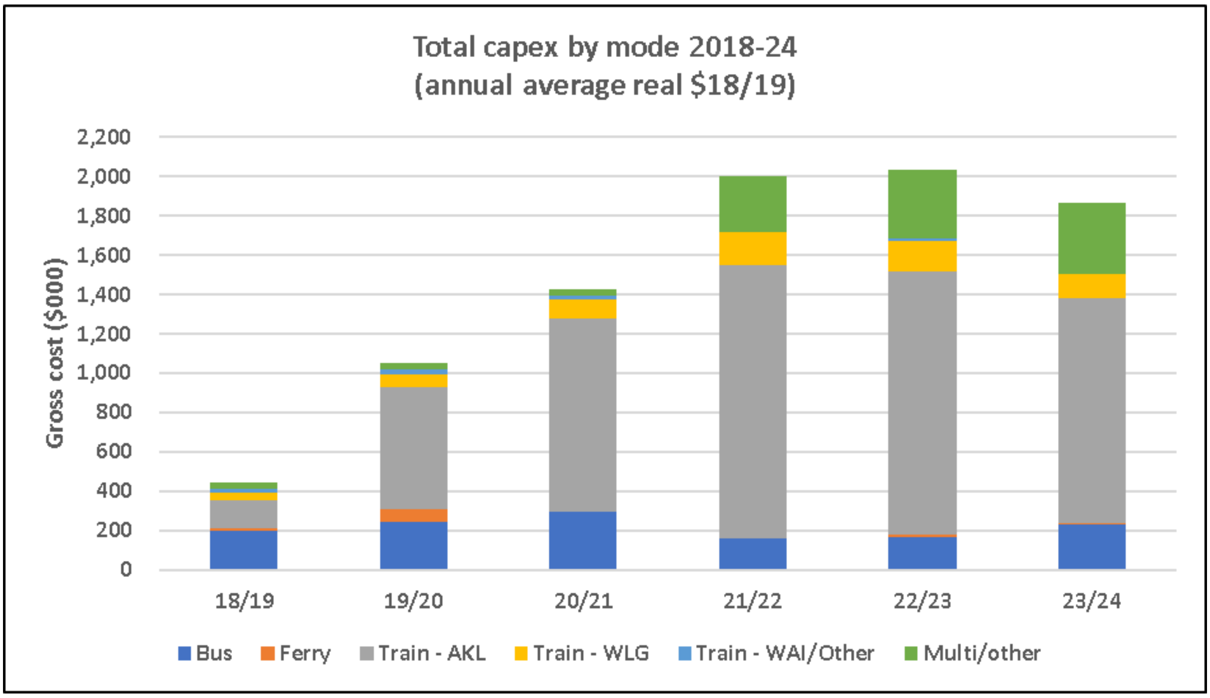
A4.2.2 Capital costs

Trends in capital costs (capex) over the six-year period are summarised in Figure D2. The picture here is much more dramatic than the trends for operating costs. Total capex is estimated to increase from some $440 mill in 2018/19 to $1,050 mill in 2019/20 and to approximately $2,000 mill in 2021/22 and to remain at around that level for the following two years to 2023/24.

Investment in rail passenger services is the dominant 'driver' of these cost increases, with the great majority of such expenditure being in the Auckland region. In the last three years of the period, the expenditure on upgrading the Auckland rail system totals nearly $4,000 million, accounting for around 70% of total PT capital expenditure nationally over that period: a large proportion of this expenditure relates to Auckland's City Rail Link scheme[69]. It should be noted that these figures do **not** include any potential expenditure on light rail or alternative rapid transit systems in the Auckland region (or elsewhere in NZ).

It is also notable that, in 2018/19, total capex was around 40% of total opex; but from 2020/21 for the remainder of the period analysed, total capex is forecast to be around 150% of opex. This represents a major shift in the financial structure and levels of expenditure in the urban PT sector in New Zealand[70].

Figure D2: Total capital costs by mode, 2018-24 ($18/19)



A4.2.3 UPT sector financial and economic performance

It is outside the scope of DTCC to give a view on whether the current and proposed major investments in the PT system in the metropolitan areas, in Auckland in particular, will prove to be justified in socio-economic terms (through applying cost-benefit analysis or similar methods).

[69] The forecast expenditures in this appendix were compiled in 2022. Subsequently, in early 2023, an updated costing for the Auckland City Rail LInk project was announced, involving an increase in capital costs of slightly over $1,000 million from the figures used in this appendix.

[70] It is also notable that, based on the NLTP data, there is little (if any) sign of the increased capital expenditure resulting in significant increases in revenues from PT users within the 6-year period: whether such revenue increases will occur in the longer term remains an open question.

A common financial performance metric in the UPT sector is the system 'farebox recovery ratio', which is essentially the ratio between money earned through passenger fares and total (gross) expenditure: a ratio of 50% is often seen as 'reasonable' for city PT systems in 'developed' countries. While practices vary between cities, the expenditure figures used in calculating the farebox recovery ratio would in many cases exclude major capital expenditures[71].

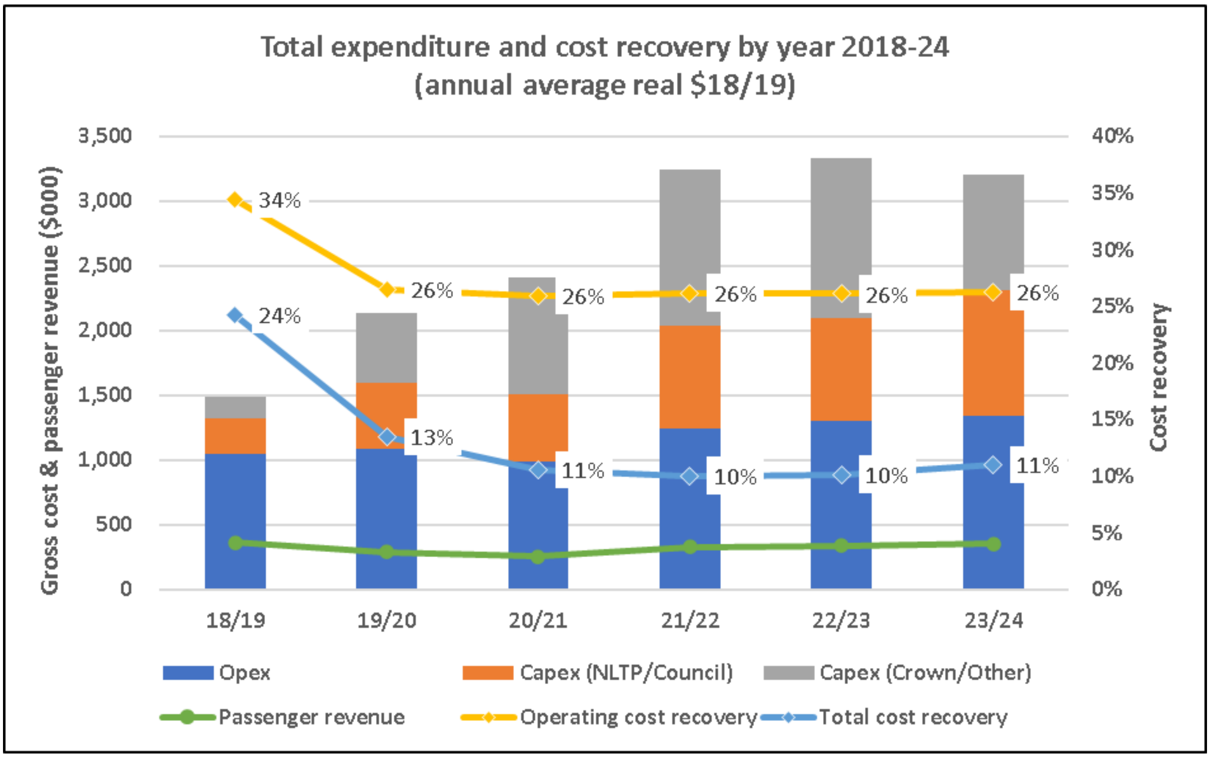
Figure D3 shows our summary of total opex, total capex and user revenues for each year of the 6-year analysis period. It also includes two lines for farebox recovery ratios, the upper line being based on opex costs only, the lower line being based on total costs (including capex). Based on opex costs only, the farebox recovery ratio starts at an estimated 34% for 2018/19, declines to an estimated 26% for 2019/20 and remains at that level for the rest of our analysis period. This 26% figure represents approximately half the 50% 'norm' target adopted commonly internationally.

The farebox recovery estimates based on total (including capex) costs are shown by the blue line in Figure D3. On this basis, cost recovery starts from a level of 24% in 2018/19, declines rapidly to 11% by2020/21 as capital expenditure is increased, and then stays at about that level for the remainder of the analysis period. [72]

[71] The farebox recovery ratio target set by Waka Kotahi until recent years appears similar to common international practice, although 'the devil is in the detail' in the interpretation of the Waka Kotahi target relative to international practices

[72] There are some analogies between cost recovery calculated on this full cost basis and the 'PAYGO' approach adopted in the NZ state highway sector, which aims to recover sufficient money through user charges to fund both capital and operating expenditures on an annual basis.

Figure D3: Total expenditure and cost recovery, 2018-24 ($18/19)[73]



A4.3 The 6-year average picture (compared with 2018/19)

Figure D4 summarises the UPT cost and revenue structures at an aggregate average level for the six-year period (2018-24). This may be compared with Figure 2.1.1, which provides the equivalent information for 2018/19.

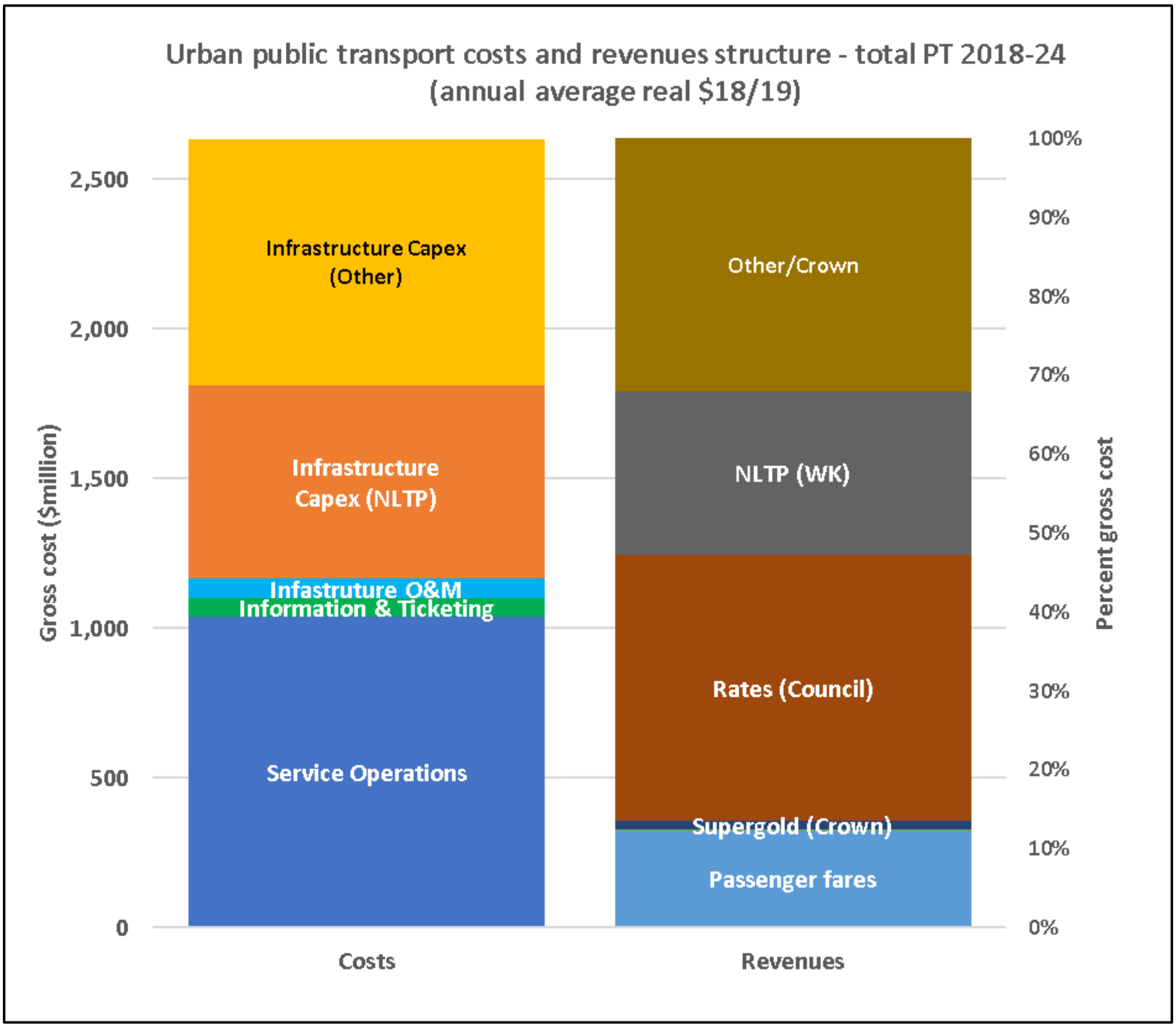
On the cost side:

- The average annual total cost has approximately doubled (in real terms) from $1,200 million for 2018/19 to some $2,600 million.
- The service operations component of the costs has remained approximately constant, at some $900 -$1,000 million per year.
- The main increase has been in the infrastructure (capex) costs, which were around $260 million in 2018/19 but increased to some $1,400 million average over the six-year period,

On the revenue (funding) side, passenger fare revenues stayed broadly constant at around $260 million a year. However, while they covered some 27% of total costs in 2018/19, in the six-year period this average reduced to some 13%.

[73] We are unclear about some of the assumptions made in estimating these cost recovery ratios, particularly in regard to future fare levels, service levels and treatment of the impacts of Covid-19 on patronage and revenues.

Figure D4: UPT costs and revenues structure, 2018 -24 average



Figures D5 (gross costs) and D6 (revenues/funding) provide greater breakdowns by mode of the gross costs and the revenue (funding) sources averaged over the six-year period (and expressed in constant real 2018/19 $ terms): these may be compared with figure 2.1.2 (costs) and figure 2.1.3 (revenues/funding) in this paper.

On the cost side, the major change is the large increase in the proportion of total costs incurred on the train mode: this proportion increased from some 28% in 2018/19 to over 50% on average over the six-year period.

In terms of revenue sources, the total passenger fare revenues shown have not changed substantially since 2018/19, on either the bus or the train modes. Correspondingly, the proportion of total costs covered by fares has fallen only slightly for the bus mode, but very substantially for the train mode.

Figure D5: Gross costs by mode and cost category, 2018 -24 average

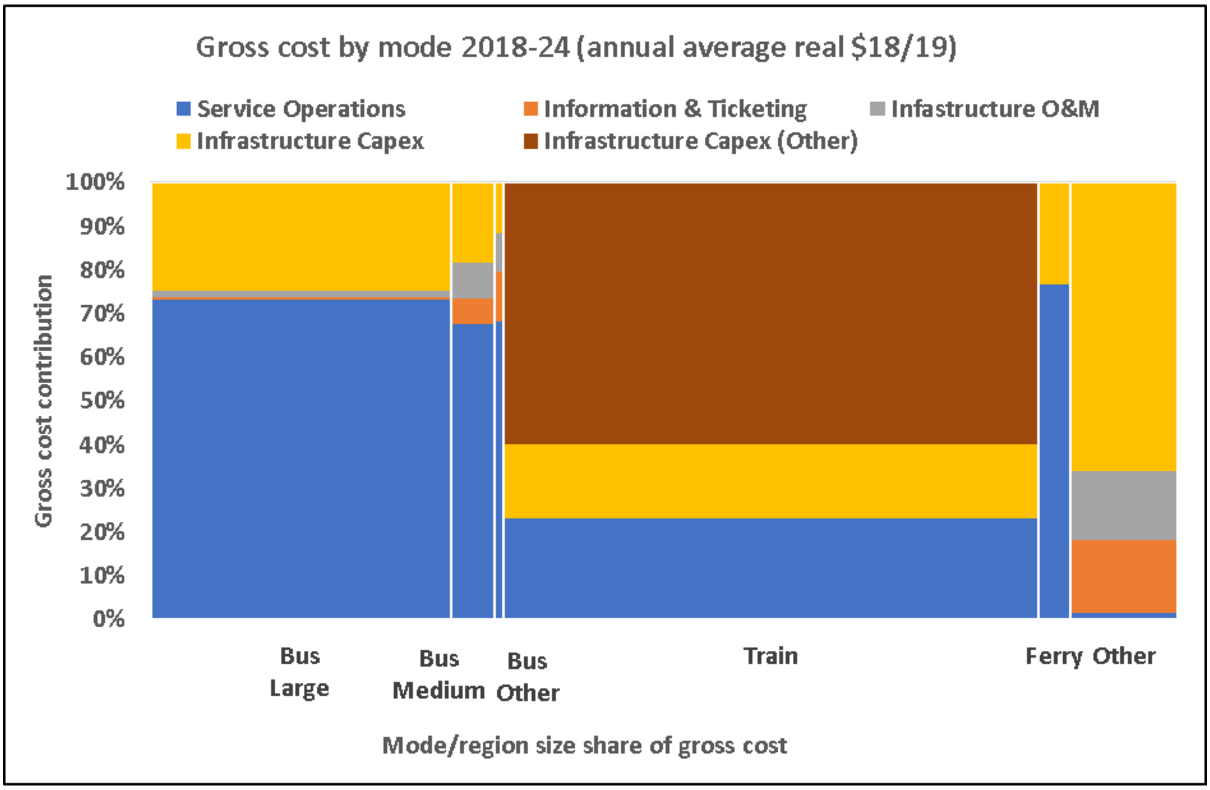
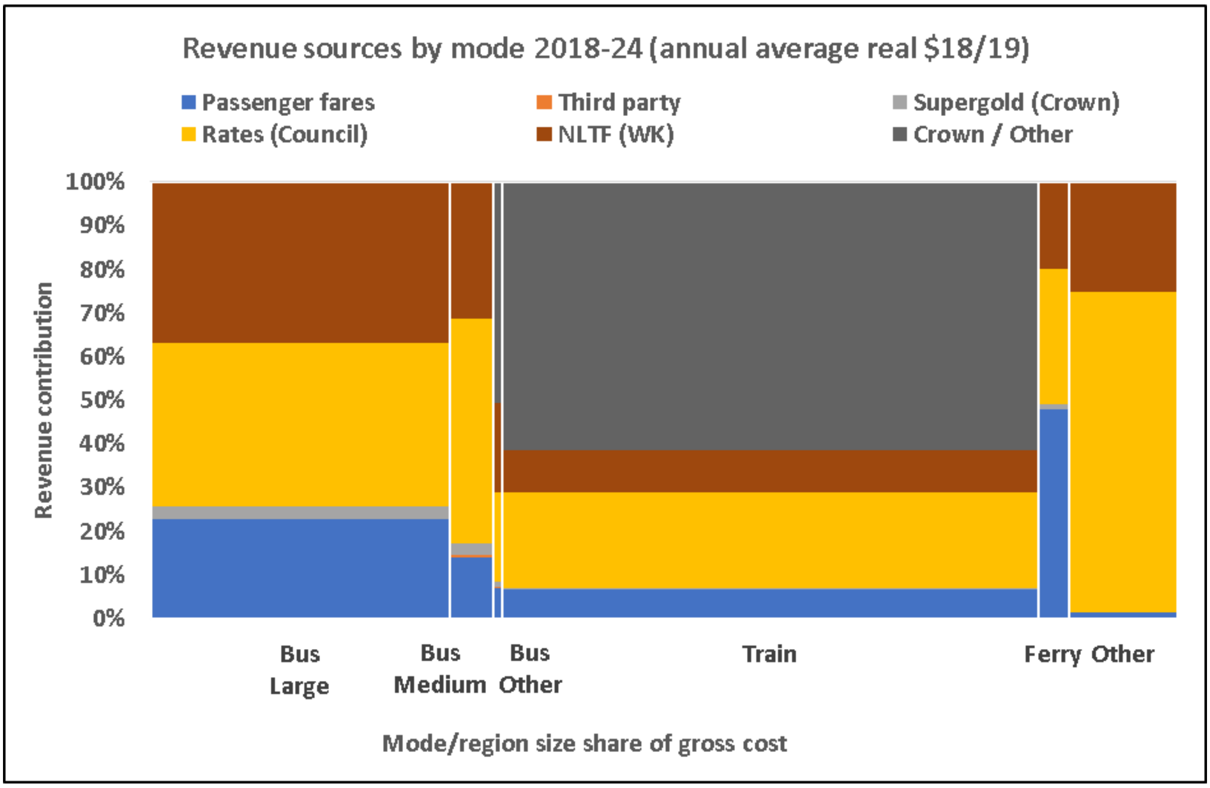


Figure D6: Revenue sources by mode and cost category, 2018 -24 average



Appendix 5 Listing of DTCC Working Papers

The table below lists the Working Papers prepared as part of the DTCC Study, together with the consultants responsible for their preparation.

Ref	Topic/Working Paper title	Principal Consultants	Affiliation
MODAL TOPICS			
C1.1	Road Infrastructure – Marginal Costs	David Lupton	David Lupton & Associates
C1.2	Road Infrastructure – Total & Average Costs		
C2	Valuation of the Road Network	Richard Paling	Richard Paling Consulting
C3	Road Expenditure & Funding Overview		
C4	Road Vehicle Ownership & Use Charges		
C5	Motor Vehicle Operating Costs		
C6	Long-distance Coaches	David Lupton	David Lupton & Associates
C7	Car Parking	Stuart Donovan	Veitch Lister Consulting
C8	Walking & Cycling		
C9	Taxis & Ride-hailing		
C10	Micro-mobility		
C11.2	Rail Regulation	Murray King	Murray King & Francis Small Consultancy
C11.3	Rail Investment		
C11.4	Rail Funding		
C11.5	Rail Operating Costs		
C11.6	Rail Safety		
C12	Urban Public Transport	Ian Wallis & Adam Lawrence	Ian Wallis Associates
C14	Coastal Shipping	Chris Stone	Rockpoint Corporate Finance
C15	Cook Strait Ferries		
SOCIAL AND ENVIRONMENTAL IMPACT TOPICS			
D1	Costs of Road Transport Accidents	Glen Koorey	ViaStrada
D2	Road Congestion Costs	David Lupton	David Lupton & Associates
D3	Health Impacts of Active Transport	Anja Misdrak & Ed Randal	University of Otago (Wellington)
D4	Air Quality & Greenhouse Gas Emissions	Gerda Kuschel	Emission Impossible
D5	Noise	Michael Smith	Altissimo Consulting
D6	Biodiversity & Biosecurity	Stephen Fuller	Boffa Miskell

Note:

The above listing incorporates a number of variations from the initial listing and scope of the DTCC Working Papers as set out in the DTCC Scoping Report (May 2020).

Domestic Transport Costs and Charges Study

Working Paper C12
Urban Public Transport

transport.govt.nz

ISBN 978-1-99-117849-7

Te Kāwanatanga o Aotearoa
New Zealand Government