Approaches to Infrastructure Pricing Study: Part 3 - Equity Exploration

A report for the New Zealand Infrastructure Commission - Te Waihanga

January 2024

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Context for this report

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Te Waihanga - the New Zealand Infrastructure Commission (Te Waihanga) has commenced a programme of work to develop an economic framework for pricing infrastructure to provide a principled, sector-agnostic baseline for future policy analysis. The economic framework for pricing infrastructure is intended to be applied across the four key infrastructure sectors (the four sectors) - land transport, water, telecommunications (telco) and energy.

To support the development of the economic framework for pricing infrastructure, Te Waihanga commissioned the Approaches to Infrastructure Pricing Study (the Pricing Study), which comprises four components:

1. **Economic framework design.** Developing the economic framework for pricing infrastructure - focused on proposed Pricing Goals and Principles.
2. **Current pricing analysis.** Undertaking analysis of the current system settings of the four sectors, to build understanding of current pricing performance against the proposed Pricing Goals and Principles.
3. **Equity exploration.** Considering the equity implications of the proposed Pricing Goals and Principles.
4. **Information assessment.** Identifying the data sources available for information on infrastructure pricing and pricing practices in New Zealand.

Each component of the Pricing Study contributes to the development of the final economic framework for pricing infrastructure. **This report focuses on Part 3: Equity exploration.**

Parts of the Pricing Study

1 Economic framework design

- Develop a set of Pricing Goals and Principles against which pricing options can be assessed
- Consider wider policy drivers and sector characteristics when developing the Pricing Goals and Principles

2 Current pricing

- Describe how infrastructure services are currently priced, the drivers/principles reflected in the pricing and consumer/user outcomes
- Use the economic framework developed in (1) to assess current pricing approaches
- Draw comparisons across the four sectors and to relevant case studies
- Summarise key sector issues
- Review and refine the economic framework

3 Equity exploration

- Discuss how affordability may be affected by different pricing mechanisms
- Explore options to address distributional equity impacts in each sector
- Qualitative assessment of options to address distributional equity impacts with reference to the Pricing Principles

4 Information Assessment

- Identify data sources available for information on infrastructure pricing and pricing practices in Aotearoa
- Summarise the form ownership and disaggregation of data
- Identify and assess data that could be used to develop a method for monitoring pricing over time
- Identify and assess asset, demand and cost drivers
- Gap analysis on data available vs data required to track pricing approaches

Transport data

Water data

Telco data

Energy data

5 Reporting

- Report on findings

Content of this report

This report consists of five key sections, as described below.

Executive Summary

Executive summary (1 of 2)

This report examines effects of infrastructure pricing approaches across three dimensions of equity:

- **Vertical equity** - how pricing distributes the costs of infrastructure across households with different levels of income.
- **Horizontal equity** - how pricing approaches distribute the costs of infrastructure across households with different base levels of need for infrastructure services. This is proxied by household size, but is also relevant for other ways that demand varies among households at similar income levels and similar locations.
- **Spatial equity** - how pricing approaches distribute the costs of infrastructure across households in different types of locations.

Our key findings are summarised below:

- The ability of larger households to economise on infrastructure services is one of the strongest determinants of average cost per person across all sectors.
- Fixed charges are consistently regressive, meaning lower income households pay more per person on average. One factor contributing to this is a correlation between higher incomes and larger household sizes, which is contrary to the common assumption that lower income households tend to have more people. Another factor is the inability to save by substituting away from the service under a fixed charge. Note that fixed charges also have no effect on usage levels. From an equity perspective, this is sometimes desirable, particularly when recovering large fixed costs not directly related to usage levels.
- Volumetric charges are consistently more progressive than most other mechanisms across sectors, specifically in terms of distribution of cost burden. However, this should be considered within the context of cost recovery for assets with large fixed costs that usually occur long before the usage that pays for them.
- For the income, geography, and household size groups examined, some sectors have more within-group variation in household demand than others. The same is true for between-group variation. This can complicate general conclusions about desirability and distributional effects of specific mechanisms.
- Development contribution charges are more progressive than commonly understood. This is partly because new greenfield developments tend to be purchased and lived-in by higher income households, and partly because most of the cost burden is likely to be absorbed out of the profit margins of landowners and developers rather than borne by homebuyers and renters. In circumstances where these charges under-recover costs of new infrastructure, a greater burden falls on lower-income households than would otherwise be the case.
- Most types of charges can be interpreted as regressive as a proportion of income, or progressive as a proportion of baseline expenditure on infrastructure of a given type. In other words, the higher burden faced by low-income households under the charge says more about the sector-wide distribution of costs and usage patterns in that sector than it does about the characteristics of the pricing mechanism itself.
- There is less variation in expenditure by both geography and income levels for transport than for telco or water, both for fixed and variable costs. This is likely related to the lack of practical alternatives to car ownership for most users.

Executive summary (2 of 2)

The table below summarises our modelled equity effects of a range of pricing mechanisms in terms of the three dimensions of equity. Both these dimensions and the quantitative modelling of price effects are presented in more detail below. For comparative purposes, the charges for each mechanism are set to raise an amount of revenue equal to household expenditure for each infrastructure service, based on the Household Economic Survey (HES). More detail on our use of the HES is provided in Section 2.

		Vertical equity		Horizontal equity		Spatial equity	
Infrastructure service	**Charge type**	**How much would people in high-income households pay relative to low-income households?**		**How much would people in large households pay relative to people in small households?**		**How much would people in dense urban areas pay relative to people in rural areas and small towns?**	
		Cost per person	**Disposable income parity**	**Cost per person**	**Disposable income parity**	**Cost per person**	**Disposable income parity**
Water	Uniform annual charge	-55% less	-90% less	-60% less	-60% less	-15% less	-15% less
	Volumetric charge	100% more	-60% less	60% more	60% more	-5% less	-5% less
	Blended fixed and volumetric	50% more	-70% less	25% more	25% more	-10% less	-10% less
	Increasing block tariff	140% more	-55% less	90% more	90% more	-5% less	-5% less
Telco	Uniform annual charge	-55% less	-90% less	-60% less	-60% less	-15% less	-15% less
	Volumetric charge	300% more	-25% less	-20% less	-20% less	490% more	490% more
	Usage-cap tariff	25% more	-80% less	-40% less	-40% less	100% more	100% more
Transport	Vehicle rego charge	-5% less	-80% less	-35% less	-35% less	About the same	About the same
	Volumetric charge	60% more	-70% less	-30% less	-30% less	-20% less	-20% less
	Congestion price	15% - 30% more	Not modelled	25% - 35% more	Not modelled	People in dense urban areas pay most of the charges	Not modelled

Note: Disposable income parity (DIP) is a measure of the burden of cost relative to income. The calculation of DIP is explained on page 20. The % figures in each equity dimension column represent the change in payment per person between the highest and lowest modelled categories for each dimension. We have excluded the development contribution charges from the table because we do not have sufficient information on household sizes for new growth areas to calculate equivalent per-person differences in charges.

1

Introduction and approach

Approach to comparing equity effects of pricing mechanisms

Approach to comparing equity effects of pricing mechanisms

The purpose of this report is to compare the equity and distributional implications of a range of pricing mechanisms used for infrastructure.

- We compare mechanisms by setting prices for each to levels that equalise the total revenue raised in each case.
- We rely on survey data for current household expenditure on infrastructure, grouped by income, household size, and geography types.
- We rely on a range of assumptions informed by research to calculate usage levels for households within these subgroups.
- We treat development contributions slightly differently, focusing instead on incidence between homebuyers and landowners.
- For simplicity, we do not consider second-order effects of users responding to changes in prices. If these were included, we expect cost distributions would become slightly more progressive across all mechanisms as more price-sensitive users choose to consume less rather than pay more.
- We examine overall household expenditure on all four sectors as well as housing and vehicle costs. We provide more detailed case studies modelling the equity effects of a range of specific pricing mechanisms. These case studies are drawn from the water, telco and land transport sectors, as well as the more general development contribution case. These are selected for their relevance to the mechanisms covered.

Table 1: Pricing mechanisms examined

Charge type	Pricing mechanism	Sector example
Fixed	Fixed per-vehicle charge for all NZ motorists	Transport
	Uniform annual charge	Telco
	Uniform annual charge per connection	Water
Variable	Variable per-usage (fuel-based) charge for all NZ motorists	Transport
	Volumetric charge per litre	Water
	Volumetric charge per gigabyte	Telco
	Per km congestion charge for Auckland only	Transport
Blended	Blended uniform annual charge and volumetric charge	Water
Block tariffs	Usage-cap block tariffs	Telco
	Increasing block tariff	Water
Connection-based	Doubling of development contribution	Transport, Water, Community facilities

Pricing mechanisms not explicitly modelled

Pricing mechanisms not explicitly modelled

There is a considerable range of pricing mechanisms used for infrastructure in New Zealand today. While we have not developed quantitative case studies for all of them, most can be understood as variations on the range of cases included in this report. We have categorised several additional mechanisms on the right according to their most comparable counterparts included in our cases.

We have not modelled these specific cases, but they can be thought of as variations on the cases we have modelled. Note that this report focuses on household charges and offers no conclusions about the equity effects of charges levied on industrial and business users.

Variations on fixed charges

- Capacity charges (e.g industrial electricity)

Variations on volumetric charges

- Fixed units of use (e.g. prepay mobile)

Variations on block tariffs

- Monthly charges with a rate of use cap (e.g. home broadband)

Variations on blended fixed and volumetric charges

- Daily charges plus a per unit component (e.g. metered water)
- Daily charges plus a time-of-use unit component (e.g. commercial electricity)

Variations on user behaviour charges

- Heavy use charges (e.g. RUC)
- Peak use charges (e.g. time-of-use charges in electricity)
- Per use charges (e.g road tolls)

2

Observations on Household Economic Survey results for infrastructure spending

Three dimensions of equity

Overview

This report examines effects of infrastructure pricing approaches across three dimensions of equity:

- Vertical equity - how pricing distributes the costs of infrastructure across households with different levels of income.
- Horizontal equity - how pricing approaches distribute the costs of infrastructure across households with different base levels of need for infrastructure services. This is proxied by household size, but is also relevant for other ways that demand varies among households at similar income levels and similar locations.
- Spatial equity - how pricing approaches distribute the costs of infrastructure across households in different types of locations.

To explore how pricing mechanisms influence these dimensions of equitable distribution, we use data from the Household Economic Survey (HES) to model how the charges faced by subgroups of the population would vary under different pricing designs. Weighted survey responses are grouped by five geographic categories relating to population density and urban form, five income quintiles, and two household size categories. The following pages present descriptive statistics in aggregate and by sector across these dimensions.

Overall expenditure on infrastructure services

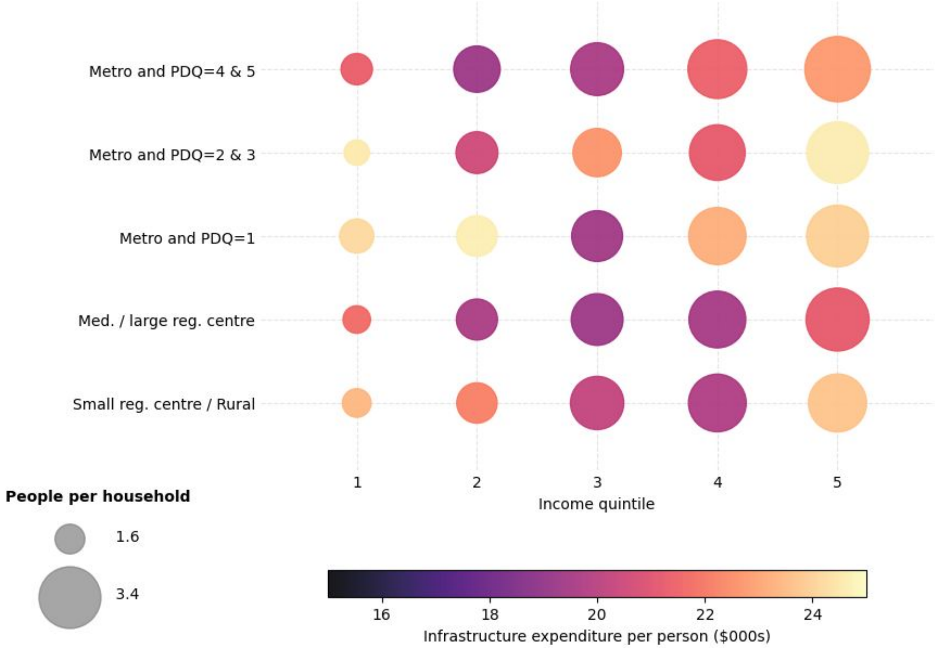
Figure 1 shows total expenditure per person on infrastructure services by each combination of geographic and income categories. The size of each bubble represents the average people per household for that group. The colour of each bubble represents the total expenditure per person on infrastructure services across all sectors. The vertical axis of the matrix compares the geography. The top row represents the most densely populated geography.

People per household and income levels: The diagram shows as household income rises, so does the average number of people per household. This may be intuitive - more earners in a home will likely mean more income - but it is contrary to a common assumption that lower income households tend to have more people.

Infrastructure expenditure per person: Household infrastructure charges are mostly derived from two broad types of pricing mechanisms, fixed charges per connection and variable costs based on volume of use. The combination of these two mechanisms results in expenditure per person rising on both ends of the household income spectrum compared to the middle-income households. Households in the high income brackets are less price sensitive and therefore use more infrastructure services and spend more via the variable component of costs. This results in high income households having a high infrastructure expenditure per person. Despite being more price sensitive, low income households tend to be smaller, and must often pay the same fixed costs associated with infrastructure services that larger households pay. Low-income households also pay more per unit under some pricing schemes, as we demonstrate in the following section.

For most geographies, the diagram shows similar expenditure per person for both the lowest and the highest income groups, despite consumption being likely to be far higher among wealthier households.

Figure 1: Household size and expenditure per person on all infrastructure services



Note: PDQ = "Population density quintile", where 1 is the least dense and 5 is the most dense. Income quintiles range from lowest (1) to highest (5). Bubble size represents people per household.

Overall expenditure on housing and vehicle costs as a proxy for cost of living

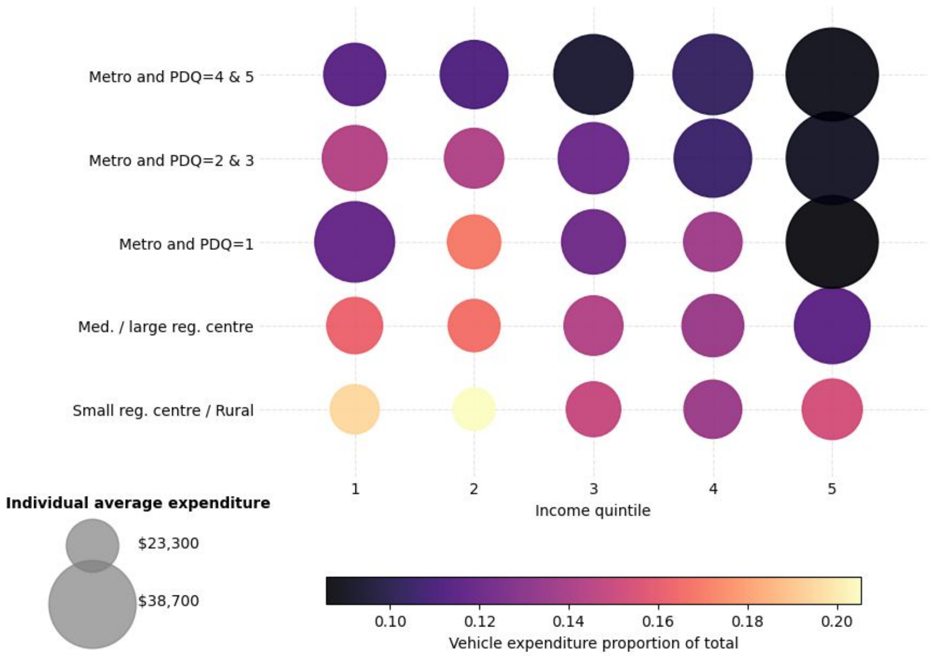
Figure 2 shows total expenditure per person on housing and vehicle capex costs by each combination of geographic and income categories. The size of each bubble represents the average expenditure per person for that group. The colour of each bubble represents the proportion of housing and vehicle expenditure that is spent on vehicle costs.

Because housing and vehicle expenditures together represent the largest portion of living expenses for most households, it is helpful to understand the distribution of these costs across income and geographies as context for the narrower examination of infrastructure service charges presented in this report.

The broad pattern of variation is intuitive. We observe greater expenditures toward the upper right corner of the figure, meaning that both earning more income and living in higher density areas correlate to spending more on housing and vehicle costs. The color of the bubbles shows that households in more densely populated areas tend to spend more on housing relative to vehicles than those in smaller towns or rural areas. As incomes increase, we also observe more expenditure on housing relative to vehicles.

There is one striking exception to these general patterns. Low income households on the outer fringes of large metro centres are spending substantially more than their counterparts in other geographies, and more than their geographic neighbours at most income levels. This group is also similar in average household size to counterparts in other geographies, though smaller than higher-income households in general. The difference appears to be driven by housing costs, which may reflect several aspects of lower cost housing on metro fringes, including those influenced by urban planning decisions and construction and infrastructure costs.

Figure 2: Expenditure per person on housing and vehicle capex costs



Note: PDQ = "Population density quintile", where 1 is the least dense and 5 is the most dense. Income quintiles range from lowest (1) to highest (5). Bubble size represents people per household.

Expenditure on transport

Figure 3 shows average expenditure per person on private and public transport services and charges. This excludes expenditure on vehicle purchases, but includes maintenance, registration fees, fuel purchases, public transport and rideshare fares, road user charges, parking charges, and other fees. The colours indicate that around 30 to 50% of these charges are variable costs.

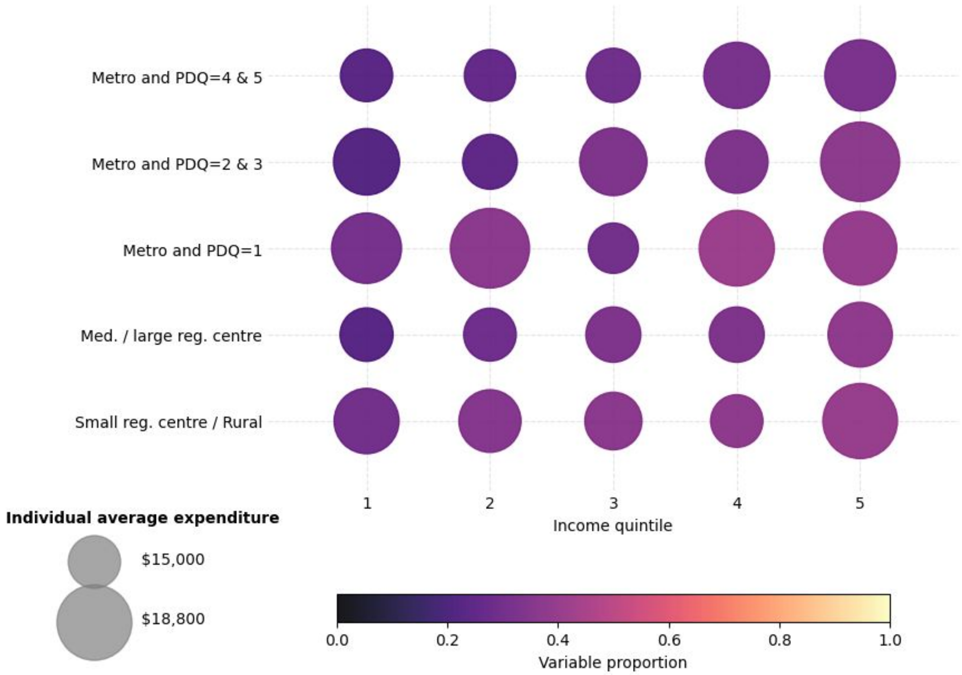
Household geography: We observe only weak relationships between geography and expenditure per person. The low-density metro areas appear to have the highest average expenditure, with the exception of the middle-income group. This may indicate a balance at that income level between being able to afford to locate in areas with access to affordable transport options and having enough price sensitivity to use them.

Income levels: Households and individuals with higher income levels spend slightly more on transport services. The middle income group shows lower expenditure on average across most geographies than either those with lower or higher income.

The absence of strong variation in averages between these groups does not necessarily mean that no strong variation exists. There may be significant variation within some of the groups, particularly in areas with access to public transport.

Note: Figures 3 through 5 use the same colour scale to enable comparison of fixed and variable costs between them.

Figure 3: Individual expenditure on transport services, charges, and fees



Note: PDQ = "Population density quintile", where 1 is the least dense and 5 is the most dense. Income quintiles range from lowest (1) to highest (5). Bubble size represents expenditure in dollars.

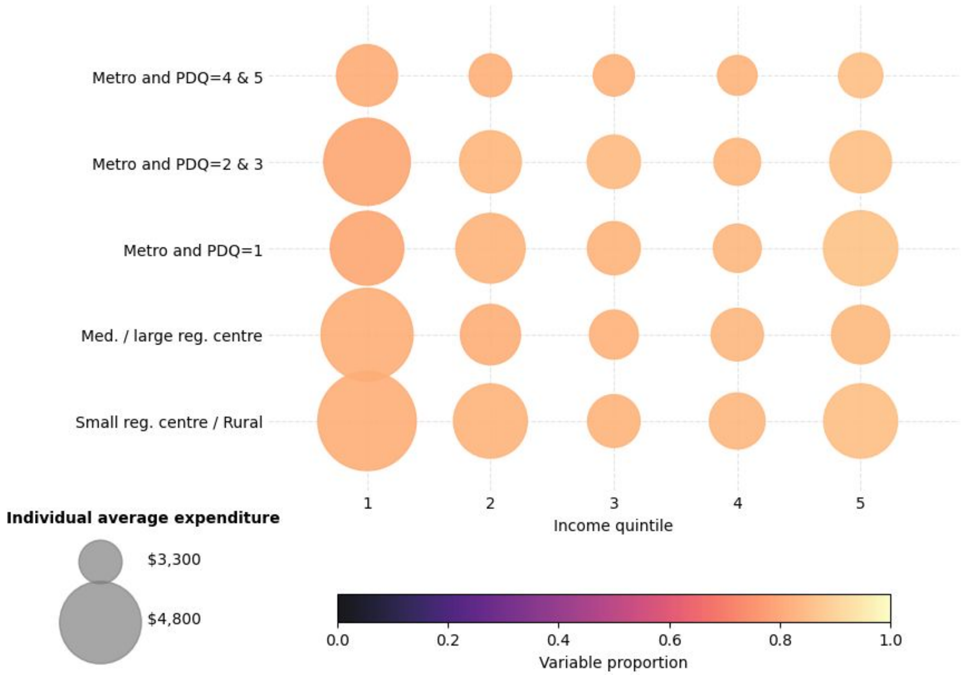
Expenditure on energy

The energy sector totals in Figure 4 are the sum of expenditure on electricity, gas, and other household fuels such as firewood. Total expenditure per person falls within a fairly narrow range, and we observe little variation in the proportion represented by fixed vs variable costs, with all subgroups showing around 80% variable costs.

Household geography: Households in the highest density metro areas are spending slightly less per person on average, across all income levels.

Income levels: The poorest households are spending slightly more per person on energy than the other groups. This may reflect smaller household sizes facing fixed costs and foregoing efficiencies from multi-person use of appliances, less energy-efficient homes, greater use of home energy as a substitute for other expenditure, or other factors. Across the four higher income groups, spending per person does not vary significantly based on income levels, meaning the main driver of household expenditure is the number of people in the home.

Figure 4: Individual expenditure on energy services, charges, and fees



Note: PDQ = "Population density quintile", where 1 is the least dense and 5 is the most dense. Income quintiles range from lowest (1) to highest (5). Bubble size represents expenditure in dollars.

Expenditure on telco

The totals for telco in Figure 5 include expenditure on fixed-line and mobile services.

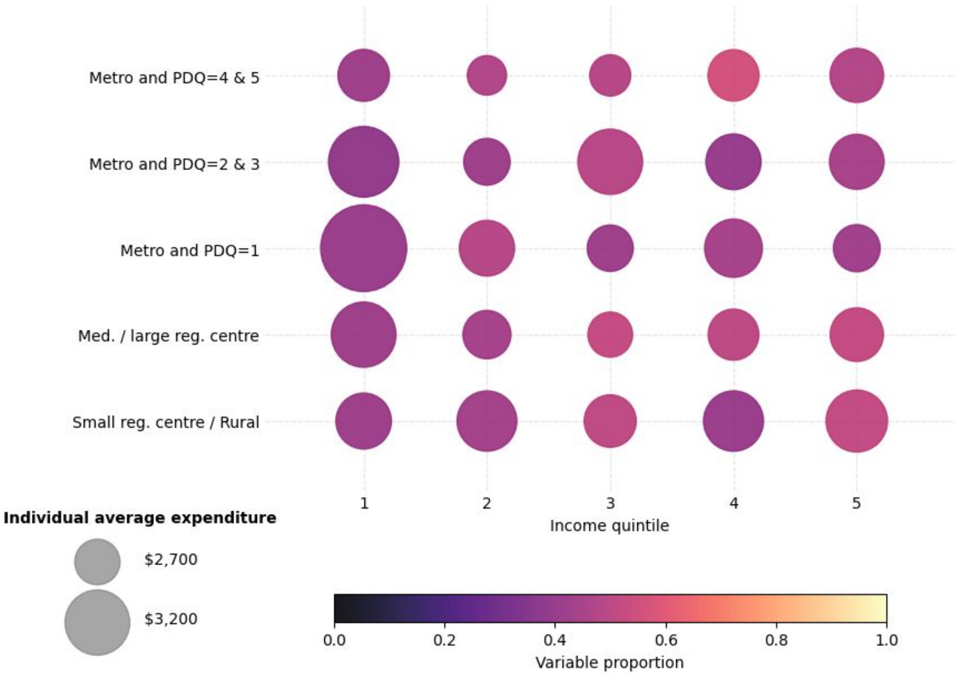
Household geography: We observe more variability across incomes for geographies in the less dense quintiles of large metro areas than for other geographies. Despite this, expenditure per person is surprisingly stable across geographies considering that the quality and types of service purchased are known to vary significantly by geography.

Income levels: An individual's average expenditure on telco services, charges and fees is greater in low income households, particularly in the lowest-density metro areas.

The lowest-income group within the low-density metro areas seems to pay more per person on average than any other group. The reason for this is not clear, but may be partly due to an allocation effect in the data associated with bundled telco and energy services. Note that on the previous page, this group shows noticeably less expenditure on energy than other geographies at the same income level. Page 13 also shows that this group spends more per person on housing than any other group at median income or below. This may be correlated with a willingness to pay more for better telco services despite little opportunity to share costs among more household members.

Telco expenditure and usage by group are explored further in the following section.

Figure 5: Individual expenditure on telco services, charges, and fees



Note: PDQ = "Population density quintile", where 1 is the least dense and 5 is the most dense. Income quintiles range from lowest (1) to highest (5). Bubble size represents expenditure in dollars.

Expenditure on water

Figure 6 shows expenditure per person on water services, including water supply, wastewater, and stormwater.

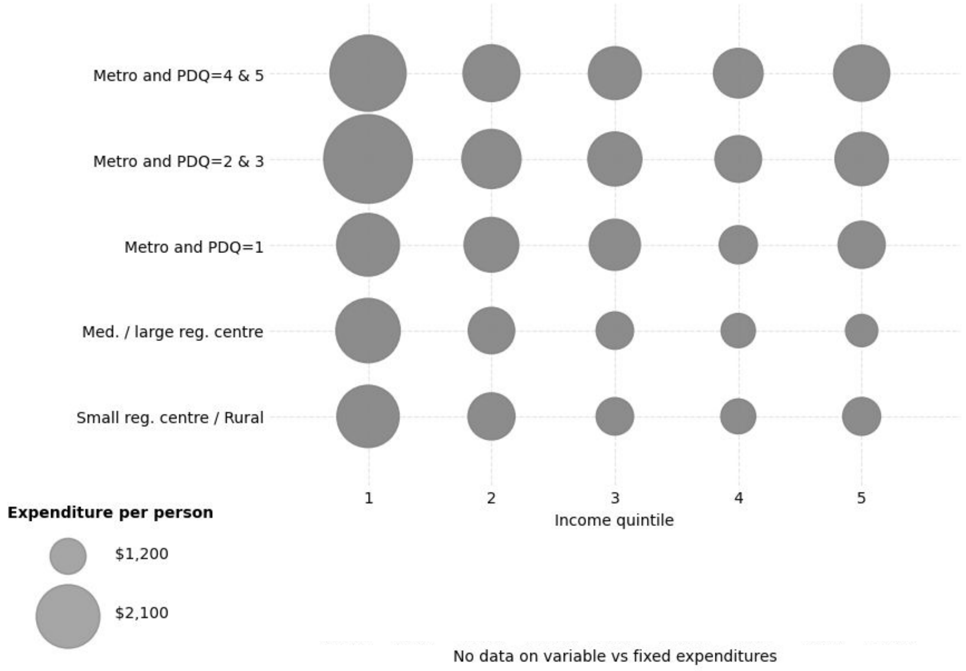
Household geography: The regional centres appear to spend less on water across income levels than the metro areas.

Household income: As household income rises the average individual expenditure on water services decreases, especially in the regional centres. Since many regions charge fixed annual fees for water, this may be a function of larger households facing a smaller portion of the same fixed fee per person. The variation by geography may also reflect the concentration of areas under per-use vs fixed-fee regimes.

Water expenditure and usage by group are further explored in the following section.

Although the sample provided shows 100% of water expenditures for all subgroups as fixed cost spending, it is well known that some districts in New Zealand charge for water on a volumetric basis. We acknowledge the limitations of the survey data in this sense and have made modelled adjustments accordingly in the analysis that follows.

Figure 6: Individual expenditure on water services, charges, and fees



Note: PDQ = "Population density quintile", where 1 is the least dense and 5 is the most dense. Income quintiles range from lowest (1) to highest (5). Bubble size represents expenditure in dollars.

3

Equity effects of pricing mechanisms for water and telco services

Quantitative analysis of selected pricing mechanisms

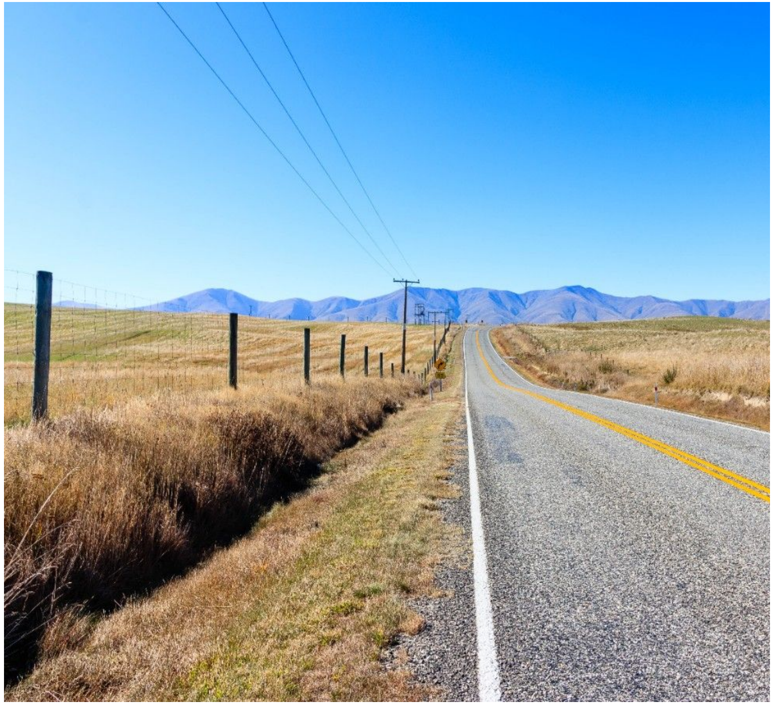
Overview

This section presents the results of modelled effects of pricing mechanisms on the distribution of infrastructure charges across the three dimensions of equity. The analysis is based on the HES results of questions related to expenditure on infrastructure services for 2017-2019, and aims to answer the question, “how would different pricing mechanisms affect who pays for infrastructure?”. In this section we focus on the water and telco sectors.

Our general approach was as follows:

- Use the HES extracts as the status quo for expenditure across five income levels, five geographic categories, and two household size groups.
- Use assumptions based on available data and literature for expected usage levels for each group.
- For each pricing mechanism, calculate potential price combinations among the groups that would result in the same sample-estimated total expenditure on each infrastructure service given our usage assumptions.

Note that for simple mechanisms such as a uniform annual charge, there will be only one implied price for the assumed usage levels. For more complex mechanisms, like tiered broadband plans, there may be many possible price arrangements.



Introducing disposable income parity as a measure of equitable cost burden

Disposable income parity overview

In the analysis below, we introduce a metric called disposable income parity (DIP) to help visualise the way a given cost or charge represents a different level of burden to households and individuals with different levels of income. The idea is to represent a given cost in terms of how much of a burden that cost would be to a median-income household. Higher values indicate that households have to spend a larger share of their after-tax income on infrastructure charges.

For example, if the median household has double the disposable income of a low-income household, $1 spent by the low-income household has a DIP value of $2. That is, the median household would have to face a $2 charge to make the burden equal in terms of proportion of disposable income.

To calculate this according to the income quintiles we use in this report, we use the median income by quintile from 2022 according to Stats NZ. We generate a set of multipliers that can be applied per quintile to any charge to arrive at the DIP value for that charge and income group. The multiplier is the ratio of the median income to the representative quintile income. Table 2 shows the multipliers used in this analysis.

Table 2: Disposable income parity multipliers (DIP22)

Income group	Group median income (June 2022)	Multiplier
Lowest quintile	14,705	2.49
Second quintile	25,586	1.43
Third quintile	36,674	1.00
Fourth quintile	50,726	0.72
Highest quintile	78,454	0.47

Assumptions

The analysis in this section relies on a range of assumptions about usage levels and how they vary by the geographic and income-based subgroups in the HES sample. Because the HES data only contains expenditure information without usage levels, we have attempted to approximate the average usage levels associated with each combination of geography, income, and household size during the same years covered by the sample.

- Water usage levels by geographic group are set using representative usage levels from selected districts and cities in New Zealand.
- Water usage levels are adjusted for income elasticity and household size elasticity, based on estimates from the literature.
- Telco usage level assumptions are informed by usage data from the Commerce Commission's Annual Telecommunications Monitoring reports. Availability of connection types by geography and their respective pricing tiers were considered in assigning variation in usage by location and income levels.
- No price elasticities in response to different charging mechanisms are considered for any mechanisms. If these were to be incorporated, we would expect cost distributions to adjust slightly in the direction of becoming more progressive or less regressive, regardless of charge type. This is because the most price-sensitive users would substitute away from the service when faced with higher costs.

These assumptions are described in greater detail in Appendix B.

Key insights

The ability of larger households to economise on infrastructure services is one of the strongest determinants of average cost per person for both water and telco.

Fixed charges are consistently regressive from a distributional perspective, meaning lower income households pay more per person on average. This is partly driven by the correlation between income and household size, and partly by the inability to save by substituting away from the service under a fixed charge. Note that fixed charges can also be desirable from an equity perspective when attempting to recover costs without distorting usage levels.

The increasing block tariff design for water is highly effective at minimising the cost burden on price-sensitive households, even overcoming the household size effect.

In telco, cost burdens by income levels respond to two broad influences:

- a huge variation in consumption levels across household types, likely correlated with individual user age*
- the ability of households to get a lower per-unit rate with a higher flat fee, which intensifies with the availability of premium services in certain geographies.

The variations in available technology for different geographies in telco combine with these two factors to create a variety of cost distributions across income levels, idiosyncratic to geography types.

The volumetric charge is by far the most distributionally progressive in telco.

* See Commerce Commission (2017). Annual Telecommunications Monitoring Report 2016. Pg. 42.

Results for water charges by income and geography

The impact on households categorised by region and income level varies under alternative pricing mechanisms.

Uniform charge

When a uniform charge is applied, lower income households pay more per litre of water than higher income households. The scale of disparity changes based on household location, but the trend is consistent. This scenario has the highest individual average charge for low income households in Metro and PDQ 2 & 3 areas.

Volumetric charge

Under a simple volumetric charge where the charge per litre of water is constant, neither household income nor location influence the price households pay for water on a per-litre basis. However, usage levels do vary by income and geography (this reflects 2021 usage data and assumptions based on the literature). The direction of variation by income is the reverse of the uniform charge - costs are now progressively distributed.

Fixed and volumetric charge

A blended approach of the two pricing mechanism results in a less severe gradation of charge per unit across income levels. The higher the proportion of revenue recovered via the fixed charge, the more severe the gradient of average cost per unit across income levels. Note that water infrastructure involves large fixed costs, so it may be appropriate from a cost-recovery perspective to charge a significant fixed price portion.

Figure 7: Uniform annual charge by HH geography

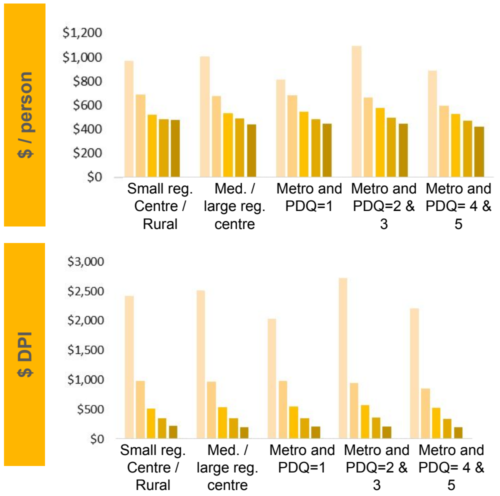


Figure 8: Single volumetric charge by HH geography

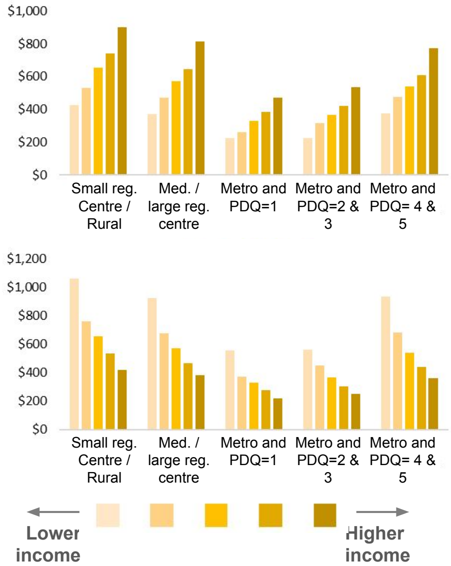


Figure 9: Blended fixed and volumetric charge by HH geography

Results for water charges by income and household size

The impact on households categorised by region and income level varies under alternative pricing mechanisms.

Uniform charge

When a uniform charge is applied to water, households with fewer individuals pay more per litre of water and lower income households pay more for water. The household size effect dominates the income effect.

Volumetric charge

Under a simple volumetric charge where the charge per litre of water does not change with usage, lower income households are able to save on costs by using less. Larger households appear to use and pay more even on a per person basis, contrary to the economising pattern seen in most sectors for this mechanism. This may be related to a correlation between household size and house typologies.

Fixed and volumetric charge

The combination of two pricing mechanisms results in a more muted price disparity per litre across households. Low-income households with one or two occupants pay the most while high-income households with three or more occupants on average pay the least.

Figure 10: Uniform annual charge by HH size

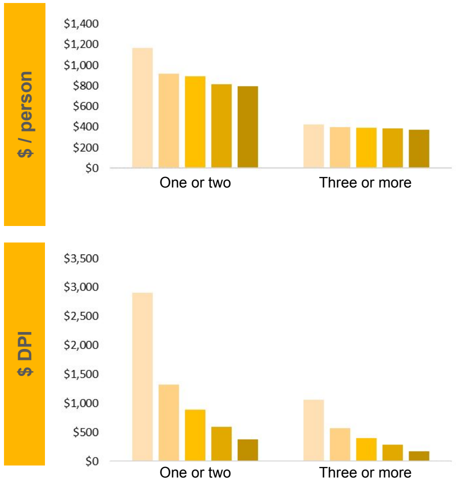


Figure 11: Single volumetric charge by HH size

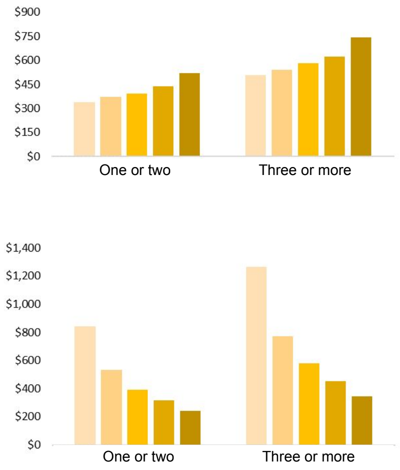
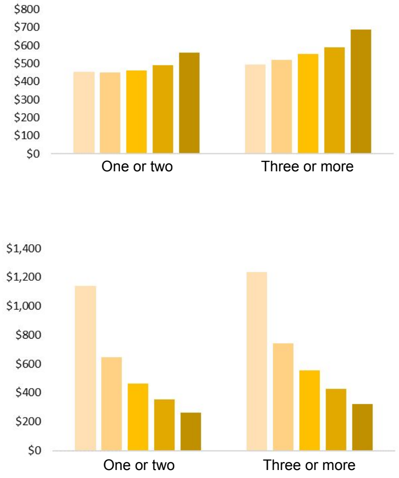


Figure 12: Blended fixed and volumetric charge by HH size



Results for water under an increasing block tariff

On the previous two slides a single volumetric charge was applied per litre of water. This meant the price per litre households would pay would not change as their consumption increases. This slide shows the results of a volumetric charge with an increasing block tariff. Under this pricing mechanism, there is an increasing marginal cost to using water. As household water usage goes up, so does the cost per litre. The effect of this mechanism on charges for different household income levels is shown below for both varying household size and geography.

HH size

The average charge per litre varies slightly between households of differing income. When the household has one or two occupants higher income households pay a higher average price per litre of water. When the household has three or more occupants this effect is diluted and there is an immaterial difference between how much households with differing incomes pay. This is likely because, as household size increases, there is a greater proportion of consumption occurring in the higher-tariff blocks regardless of income level.

HH geography

Households with higher income levels pay a greater average charge per litre consistently across geographies. This arises from the increasing marginal cost for higher usage, and is intended in the design of this mechanism. There are some slight differences in the average charge per litre based on household location, however this relationship varies based on household income, with the lowest income households varying the most by location.

Figure 13: Increasing block tariff by HH size

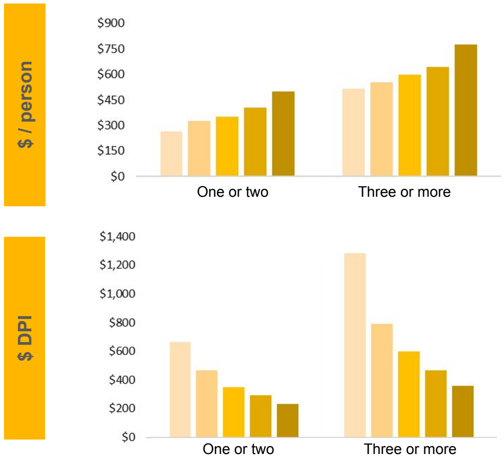
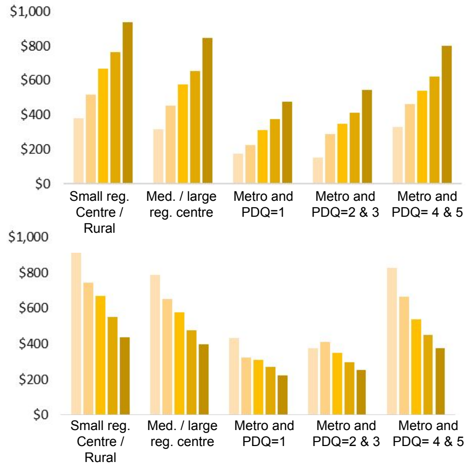


Figure 14: Increasing block tariff by HH geography



Results for telco charges by income and geography

The impact on households categorised by region and income level varies under alternative pricing mechanisms, with lower income households in the areas least densely populated expected to pay the most per gigabyte (GB).

Uniform charge

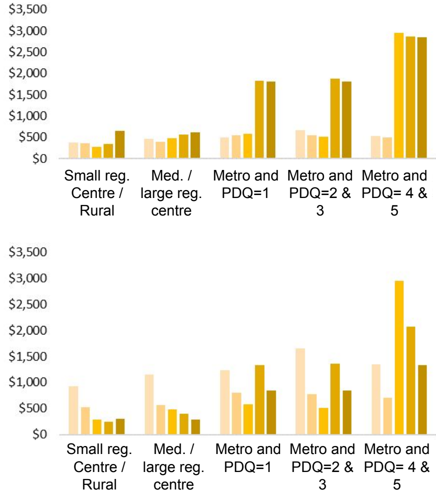
A uniform charge for telco creates significant price disparity across household income levels and locationally. Households in the lowest income bracket in the least dense regions can be expected to pay significantly more on average per GB compared to households in the highest income bracket in the most dense region. Note that because we have combined mobile and broadband usage, average cost per GB will be higher than those for broadband alone.

Volumetric charge

Under a simple volumetric charge where the charge per GB of data does not change with usage, neither household income nor location influence the price households can expect to pay for data.

Figure 15: Uniform annual charge by HH geography

Figure 16: Volumetric charge by HH geography



Results for telco charges by income and household size

The impact on households categorised by region and income level varies under alternative pricing mechanisms, with lower income households in the areas least densely populated expected to pay the most per GB.

Uniform charge
A uniform charge for telco results in a steep gradient in per unit charge by income level, but little difference in this relationship according to household size. The larger households within each income level pay slightly less per GB than smaller households.

Volumetric charge
Neither the size of the household nor income level of households influences the average charge per GB when a single volumetric charge is applied.

Figure 17: Uniform annual charge by HH size

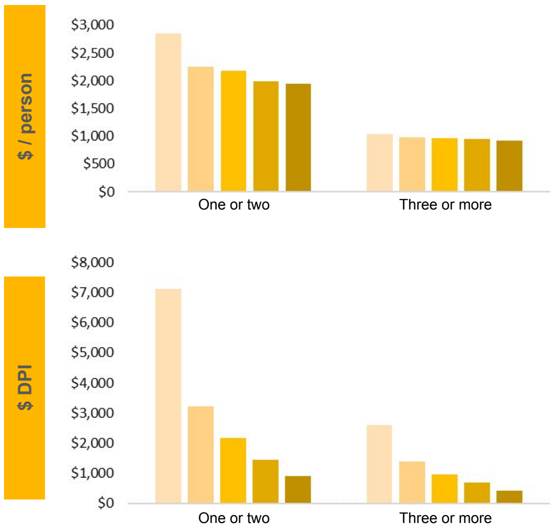
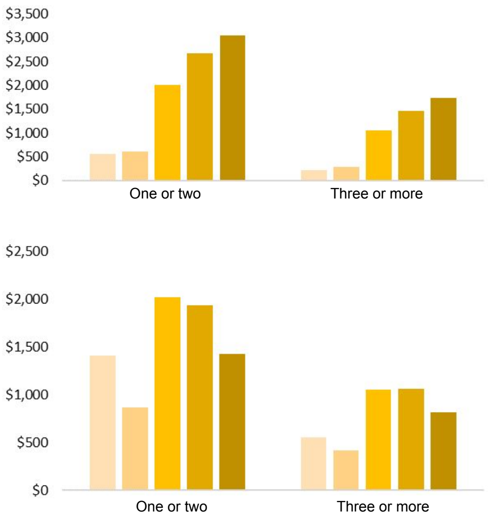


Figure 18: Volumetric charge by HH size



Results for telco charges under alternative mechanisms

On the previous two slides a fixed volumetric charge was applied to telco usage. This meant the price for telco which households pay would not change as their data consumption changed. This slide shows the results of a volumetric charge with capped tariffs at decreasing cost per unit for increasing price points, up to unlimited usage at the highest tiers. Under this pricing mechanism, there is a decreasing marginal cost to using more data. Therefore as household data usage goes up, the average cost for each GB goes down. The impacts of this pricing mechanism on different household income levels are shown here for both varying household geography and size.

HH geography

Due to the assumption that lower income households use less data, the decreasing block tariff results in lower income households paying on average more per GB than higher income households. The location of households also affects the price inequality, with households in relatively less dense regions tending to use older technology and pay more per unit of data than households in regions of higher density.

HH size

When the usage-cap tariff system is applied, the size of the household has an immaterial impact on the average charge per GB. However lower income households will have to pay a higher average charge per GB. For households of any size there is a significant difference in expected charge per GB when comparing households in the highest and lowest income brackets.

Figure 19: Usage-cap tariffs by HH geography

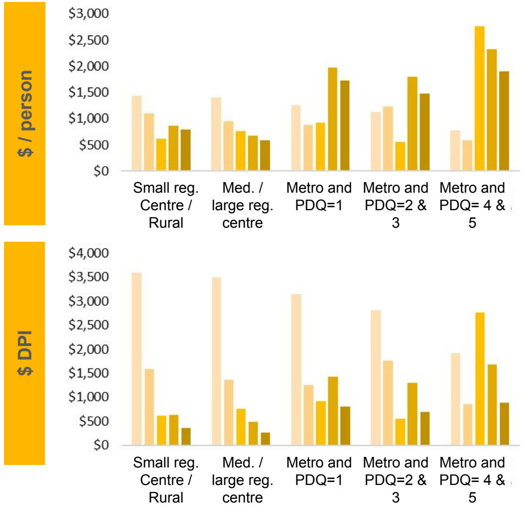
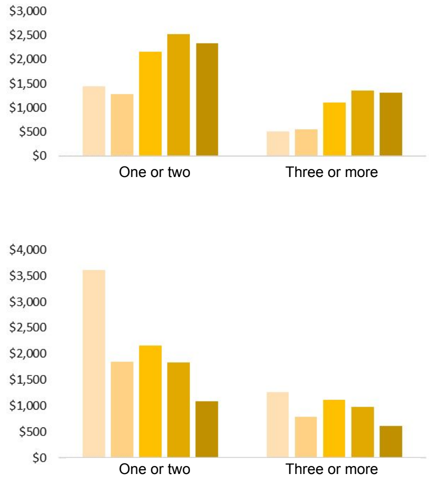


Figure 20: Usage-cap tariffs by HH size



4

Equity effects of changes in development contribution prices

Quantitative analysis of an increase in development contributions

Overview

This section presents the results of modelled effects of doubling development contribution (DC) charges on households of varying income levels. It also examines how the distribution of the charges affects homeowners and landowners differently.

The purpose of this analysis is to explore how the DC mechanism interacts with the three dimensions of equity, but these dimensions manifest differently in this case study compared to those focused on other pricing mechanisms. This is partly because the mechanism itself is more targeted at new growth in the network rather than the entire asset base and partly because the available data differs. We examine vertical equity using household income, but we use income brackets based on published Stats NZ categories rather than IDI categories. We examine horizontal equity in terms of incidence between developers and homebuyers because this is a relevant policy question and we do not have data on household size by income levels for these households. We examine spatial equity from the perspective of how charges are distributed differently for new growth suburbs vs city-wide averages.

Note that for simplicity the change in DC was only analysed under a scenario where the DC is doubled compared to recent Auckland-wide averages. In reality, the change in DC could be much greater for greenfield development areas (as is proposed in Drury). However, the impacts derived from comparisons across HH income brackets and between homeowners and landowners should hold true regardless of the magnitude of the change in the DC charge.

The specific assumptions and calculations used for the analysis are described overleaf. The key steps to the approach were to:

- Identify areas where significant urban growth has occurred over a defined recent period and the distribution of incomes for households living in these areas
- Quantify the distribution of new residential unit values for units built over this same period, to allow estimation of approximate matching between consented unit value and resident income distributions
- Estimate development contribution payments made by developers of new-built homes in these areas
- Consider the distribution of these charges between developers or landowners and households purchasing these houses.

Key assumptions

In order to analyse the equity effects of a change in the DC charge across various HH income groups and make comparisons across different stakeholders (landowners and homeowners), some assumptions for costs, housing unit values and cost distributions were made. These assumptions are outlined below.

Unit value by income group: Data on the value of all residential units (as defined in residential consent data by Stats NZ - this could be a single apartment or a three-bedroom home for example) consented in New Zealand from 2009-18 is used to derive our unit value for each income bracket. A unit represents a consented new residential build that was consented during our analysis period. The unit value assumption for each income bracket is based on the distribution of consented units over that period, both Auckland-wide and specifically for greenfield development areas. We align these consented unit values to the income groups by creating unit value bins that correspond to each income bracket. The implied assumption is that higher income households will purchase higher-value units on average, and vice-versa. Table 3 shows the consented unit values assigned to each income bracket for the Auckland Region and Greenfield SA2 areas. These are used as a proxy for unit price.

Table 3: Assigned value per unit

Location	Income bracket						
	$20,000 or less	$20,001-$30,000	$30,001-$50,000	$50,001-$70,000	$70,001-$100,000	$100,001-$150,000	$150,001 or more
Auckland Region	267,937	317,964	373,367	434,319	513,266	720,500	1,443,488
Greenfield SA2s	265,140	307,306	359,690	436,943	510,939	638,176	1,149,450

DC charge by income group: The methodology used by Auckland Council to assign a DC charge is based on multiple factors, resulting in a final DC charge that varies significantly by location and by the size of the development. For simplicity, we assume similar location-based average charges in all brackets (as this does not vary systematically by the income of eventual residents). However, as we observe above that higher income households tend to be larger on average (see section 2), we vary the value of household unit equivalents (HUEs) assigned to each income bracket. We have assumed a 10% adjustment for each successive bracket, using a HUE of 1.0 for the middle income group as our base. We also assume that for a given increase in DC charges, developers will pass on 30% of the additional charge to homebuyers. The historical (2009-2018) Auckland-wide average DC value used to assign our final DC cost is $14,738. The individual annual values were calculated by taking the annual DC revenue in Auckland divided by the buildings consented in the previous year.* The final DC charge by income group and the assigned HUE are shown in Table 4 below. Note a lower HUE directly results in a lower DC charge and implies a smaller home.

Table 4: Assigned DC charge by income bracket

Variable	Income bracket						
	$20,000 or less	$20,001-$30,000	$30,001-$50,000	$50,001-$70,000	$70,001-$100,000	$100,001-$150,000	$150,001 or more
Proportion of HUEs per household	0.75	0.83	0.91	1.00	1.10	1.21	1.33
DC charge per new unit by income	11,073	12,180	13,398	14,738	16,212	17,833	19,616

**lagged consents are used to reflect the timing gap between building consents (which trigger a DC assessment) and their payment later on (i.e. when a code compliance certificate is issued).*

Key insights

Of all the mechanisms for infrastructure pricing, DCs are likely to have the weakest implications for vertical equity, while implications for spatial and horizontal equity are counter intuitive. This is partly because new greenfield developments tend to be purchased and used by higher income households compared to city wide averages, and partly because a significant portion of the cost burden may be borne by landowners and developers rather than homebuyers and renters.

Housing purchase decisions and prices are driven by mortgage affordability, which is sensitive to interest rates and household incomes. DCs are a small portion of house prices compared to land value and construction cost components.

Household incomes of people buying or renting new-build homes tend to be higher, so funding growth infrastructure from DCs is likely to be substantially more progressive than funding it from rates.

A large part of the value of land is created by regulatory privilege - zoned and subdivided plots are scarce, and infrastructure provision is the most important factor creating that scarcity.

The costs of infrastructure recovered by DCs are a small portion of the value created by the infrastructure and accompanying market scarcity. The excess value is captured by landowners.

Even if landowners could pass 100% of DCs on to homebuyers, the difference in monthly mortgage payments would be less than 5% for all income groups.

Average income in greenfield areas vs city wide averages

One of the common concerns with using DC charges as a mechanism to recover the cost of infrastructure is that they might increase the prices of new homes for homebuyers and renters in the greenfield growth areas where they are levied. It may sometimes be assumed that households moving to new growth suburbs have lower incomes on average compared to the rest of the city, and because of this it might be desirable to have general ratepayers subsidise some of the costs of new growth.

It is relevant to an examination of equity implications of DC charges to understand whether and how severely this is the case. The figures below compare the income levels of households living in new greenfield growth areas with city-wide averages for three urban areas in New Zealand. We focused on greenfield areas because it was easier to identify household incomes of people buying or renting new-build homes in these locations.

In all cases (and for New Zealand in total), households in recent growth suburbs have higher incomes on average than the general urban population. This may reflect the affordability of feasible price-points of newly built homes, the income levels of households interested in moving during this period, or a range of other factors.

Figure 21: Income distribution for new greenfield residents - Auckland

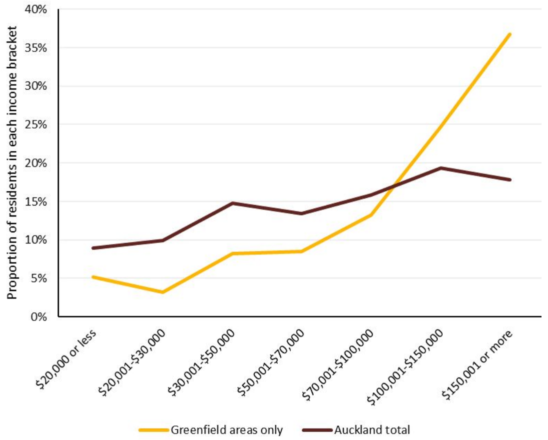


Figure 22: Income distribution for new greenfield residents - Christchurch

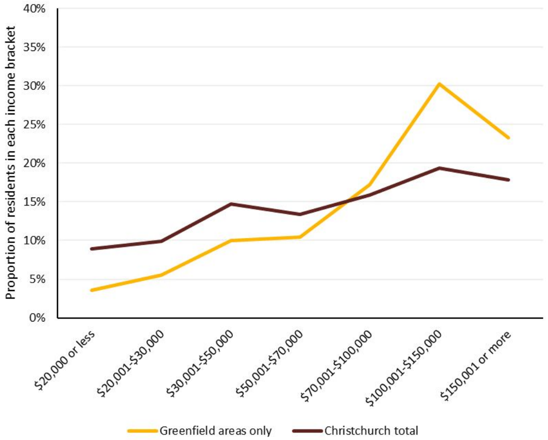
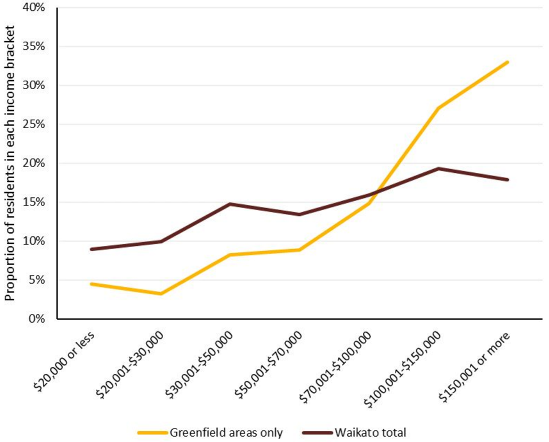


Figure 23: Income distribution for new greenfield residents - Waikato



Source: before-tax income data from 2018 Census household income data. The greenfield areas are defined as statistical areas where population in 2018 was at least 5 times higher than population in 2006.

The DC impact across varying HH incomes

The magnitude of the impact the DC has on homeowners varies based on the value of the consented home. Our chosen assumptions for HUE variation mean lower gross DC charges for lower income households, but this effect is outweighed by the stronger variation in home value by income levels. As a proportion of the consented values, lower income households pay more for infrastructure. For context, infrastructure costs are only weakly influenced by home values (primarily through unit size).

Figure 24 shows the DC as a proportion of the house price by income brackets for both greenfield and Auckland-wide consents. There is a similar range for the two groups, with greenfields showing slightly higher proportions in the upper income groups.

Figure 25 compares the portion of DCs passed on to homeowners across income levels within the Auckland Region. The cost of the increase in house prices due to DCs will be absorbed into a home loan and experienced as a small increase in monthly mortgage payments. The effect amounts to an increase in monthly payments of around $20 to $35.

Households in lower income brackets face lower DC charges than high income households in absolute terms due to our assumption that their homes are generally smaller. Compared to either house price or household income, the burden of this cost is relatively higher for low income households. However, this should be weighed against the distribution of burden for the alternative. If infrastructure costs were instead passed to citywide ratepayers, more of the burden would be borne by lower income households compared to if DCs recover the full cost of new infrastructure. This can be seen by comparing the Auckland-wide vs greenfield-only median household income levels in Figure 25.

Figure 24: Expected DC charges as a proportion of average consent values

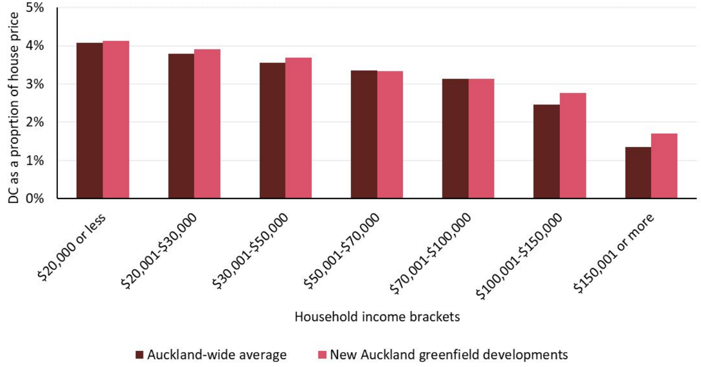
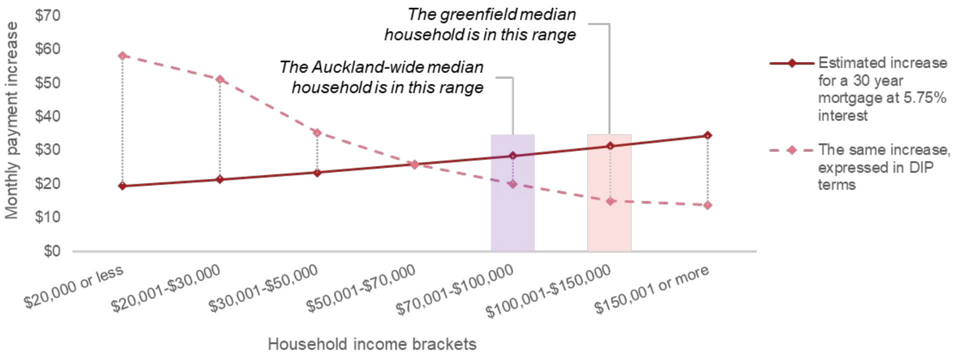


Figure 25: Increase in monthly mortgage payment from a doubling of historical DC charges, by income group



The pass-through of DCs from developers to homeowners

The pass-through of a cost increase depends on the relative bargaining power and available substitutes between buyers and sellers (relative elasticities). We can simplify the potential balance for a given set of new home purchases into three broad possibilities.

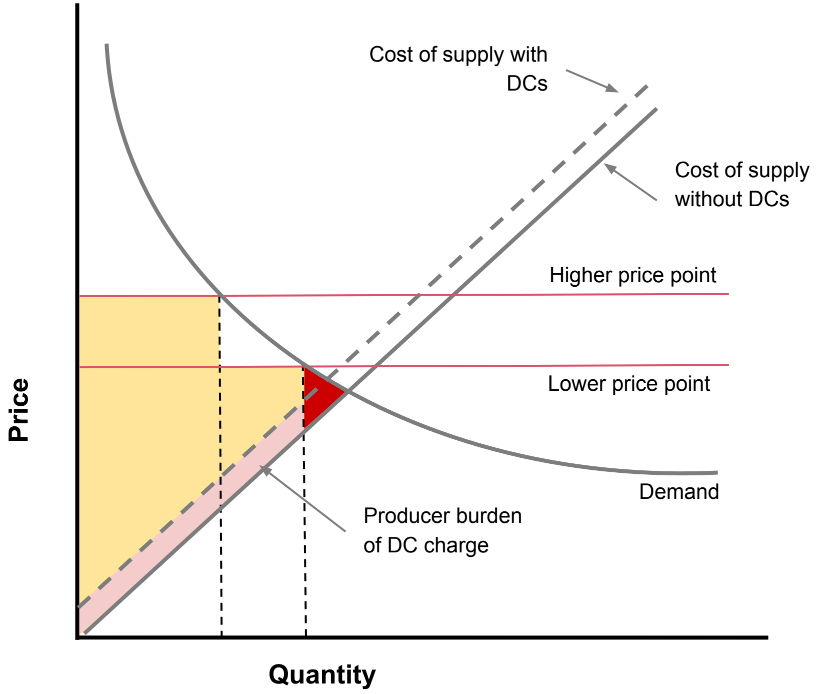
The first is that landowners are price-takers, homebuyers have many attractive substitutes, prices are competitive and near costs for suppliers. If this were the case, DCs are being passed on to home-buyers as a result of the close relationship between market price and cost of supply created by competition. The consumer has plenty of surplus to absorb an increase in charges market-wide.

At the other extreme, homebuyers are price takers, landowners have enough market power to push prices close to the maximum willingness to pay, homebuyers often settle for less than ideal purchases because they have no better options, and prices are well above the costs of supply. If this is the case, DCs are not passed to consumers, as the consumers have no surplus left to absorb them. An increase in DC would have little effect if any on house prices but would reduce landowner surplus a bit.

A more likely scenario is that the market is somewhere between these two situations. In this case, some portion of DCs will be passed to consumers but not all. The proportion passed on will depend on how close we are to one or the other of the scenarios above.

In housing markets, leverage between buyers and sellers varies a lot over time, by location, and importantly, by market segment. Developers are able to price-discriminate by targeting different parts of the market with different housing typologies and price points. Lower income buyers are much more likely to find themselves near their maximum willingness to pay than higher income households, and the scarcity at any given time of infrastructure-enabled land suitable for low-market new-builds means that even low-end price points are likely to be above costs due to developer market power. This is illustrated by the red triangle in Figure 26, and implies that under the right circumstances, DCs could possibly be fully absorbed by suppliers without distortion in the quantity of housing sold. Further study would be needed to assess the actual incidence of these charges in specific times and locations. In the case study below, we test a range of assumptions for the rate of pass-through.

Figure 26: Pass-through incidence with price-discrimination and zero distortion



The DC impact on landowners compared to homeowners

The DC charge to developers may be passed on to homeowners to an unknown extent. This can lead to DC charges influencing the prices paid for housing in new developments. One perspective in policy discussions is that DCs should not be increased despite infrastructure costs increasing, as this may lead to higher prices for the eventual homeowner. Because we assume that most homebuyers are making purchases at or near their willingness to pay for a new home (as determined by the mortgage payments they can afford), we model a 30 percent pass-through rate as a baseline assumption. This means that 70 percent of the DC cost is absorbed by the developer or landowner. Sensitivities to this assumption are shown in Figure 27.

The capacity of landowners to absorb DC charges depends, in the simplest case, on the price at which they acquired the land. In this case we assume landowners have purchased land in future urban zones (FUZ), before development announcements. According to Auckland Council estimates used for financial cost modelling of the Drury development contributions policy, land values are expected to undergo a 9.0x increase on average as land transitions from FUZ to fully zoned, infrastructure-enabled and subdivided for development.

Figure 27 shows how land owners (assumed to also be the developer) and homeowners (who have a mortgage) in Greenfield SA2 areas are affected when the current DC charge is doubled.

Homeowners: Across the seven income brackets, the average increase in monthly mortgage payments is 1%. This equates to an average increase in monthly mortgage payments of $26. Even at a pass-through of 100%, the lowest income group only sees an increase of 4.2% in their monthly mortgage payment.

Landowners: Landowners experience a much greater financial effect when there is an increase in the DC charge (Figure 28). On average, a doubling of the DC charge results in total landowner profit per unit decreasing by 4.0%. This equates to a $10,505 per unit reduction in modelled pre-tax profits.

Even after the infrastructure costs associated with the development of the unit, landowners see significant returns on their investment if they have purchased greenfield land early enough. Moreover, if DC policies are not transparent ahead of time, landowners may add a risk margin to their calculations to hedge against the possibility of higher DCs. This hedging behaviour may create similar costs for households as a DC increase even if no increase takes place.

Figure 27: DC increase effect on land owners and homeowners

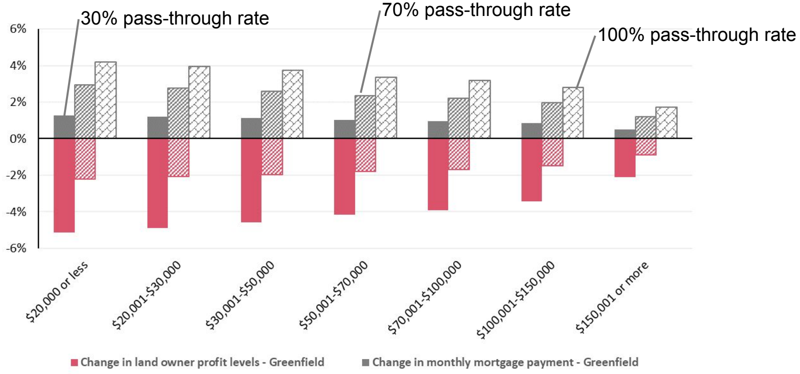
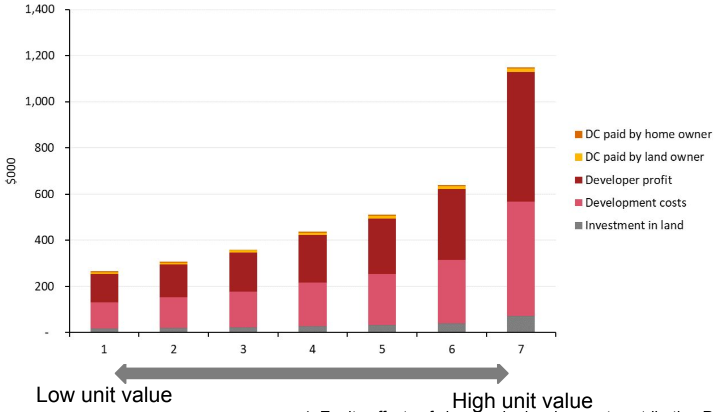


Figure 28: DC uplift impact on developer profits



5

Equity effects of pricing mechanisms for road transport

Quantitative analysis of a congestion charge for strategic corridors

Overview

This section presents a summary of analysis by Covec & MRCagney (2018) on the distributional impacts of congestion charging in Auckland. While the authors examined four different pricing schemes, we have focused only on the ‘Strategic Corridors’ scenario, which illustrates the congestion charging approach for comparison to other mechanisms. This was one of four options for a congestion charging mechanism evaluated in that report. Some of the other options had smaller equity impacts, but also smaller estimated reductions in congestion.

The Strategic Corridors scheme involves a charge of $0.12 per km for travel along the major arterial routes of the road network during morning and evening peak hours. The figures in the following pages reproduce and recombine results from that paper without altering them. The commentary is ours.

The distributional effects of this scheme are then compared in the subsequent subsection to two alternative ways of raising the same amount of revenue as the Strategic Corridors congestion charge. We examine two scenarios, both of which collect revenue from all New Zealand motorists rather than only those driving on strategic corridors within Auckland. While the total user base differs between the congestion charge and these mechanisms (all motorists vs motorists driving on certain roads in Auckland), we consider the comparison relevant for two reasons:

- The two schemes serve the same group of potential users. All motorists in New Zealand have the option of driving on strategic corridors in Auckland if they choose to travel there. Notice the similarity between this and a volumetric vs fixed charge comparison for, say, water. Some users may have access to the water network but actually use it very rarely, the same way motorists in Christchurch may only drive in Auckland once a year or less.
- The current funding regime for transport often uses funds raised from national user charges such as PED and RUC to support investment in the larger cities. In this sense the comparison is directly relevant to current policy debate.

Note that the Covec & MRCagney report uses a different breakdown of household types and incomes than the HES data does, though this still allows for comparison of impacts between income levels and household sizes.

Key insights

A congestion charge can be interpreted as regressive as a proportion of income, or progressive as a proportion of baseline expenditure on travel. In other words, the higher burden faced by low income households under a congestion charge says more about the sector-wide distribution of costs and usage patterns in transport than it does about the characteristics of the congestion charge itself. This pattern is also relevant to other infrastructure sectors.

Lower usage at peak times appears achievable in approximately equal proportion to the level of cost increase for usage, at least for the scenario examined here. Other pricing mechanisms will not influence time of use or reduce congestion.

As in the other sectors, pricing by usage allows households to have more control over their transport costs, so a usage based charge becomes more progressive than a fixed per-vehicle charge.

There is less variation in expenditure by geography for transport than for telco or water, both for fixed and variable costs.

Variation by household size follows the same pattern observed elsewhere as larger households are better able to economise.

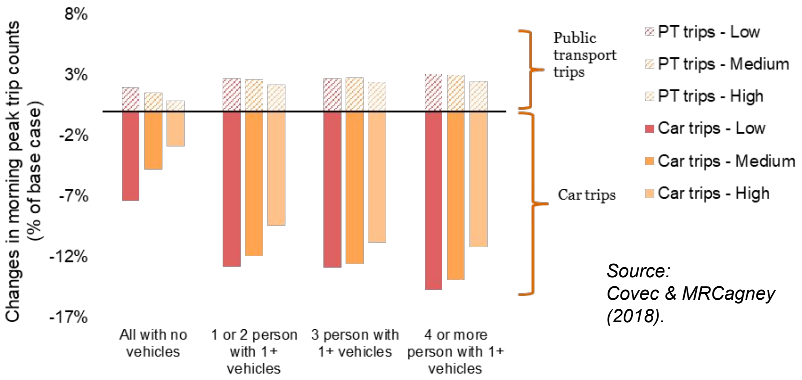
Responses to a per-km congestion charge on major corridors

The figures to the right show the estimated demand response for travel during the morning peak. Some trips have shifted from private vehicles to public transport, others may be delayed or foregone. The responses are grouped along the horizontal axis by income level (low, medium, high) and by household makeup in terms of number of persons and number of vehicles. Note that the different household types have different baseline trip counts for car and PT trips.

The demand responses are based on the Auckland Forecasting Centre's Macro Strategic Model, which uses a generalised cost (incorporating time, vehicle, fuel, fare, and fee costs) comparison between routes, modes, times, substitution of destinations or origins, and trip-chaining arrangements. These responses are then further adjusted by the authors, who apply income and price elasticities from the literature to account for potential trip suppression in response to the charges.

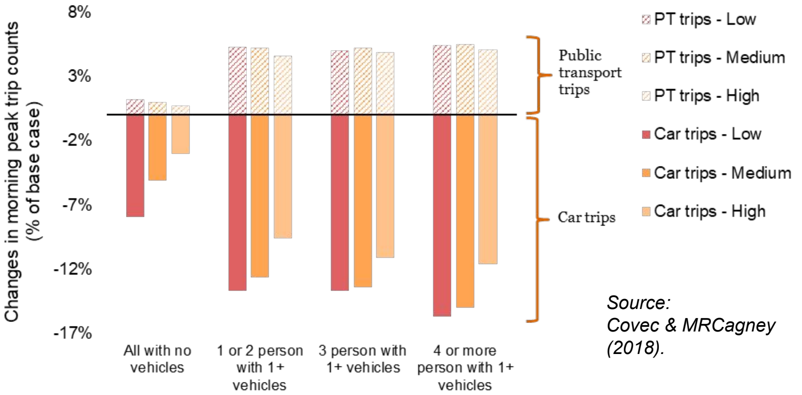
The results are intuitive. Higher income households show lower sensitivity to the additional charge for peak travel. Households with no vehicles are significantly less affected overall, and households with more people and therefore more baseline travel demand have slightly higher sensitivity to the price increase. Overall responses may seem fairly mild, as the most sensitive group (low income, high travel demand households) only shows about a 15% decrease in car trips during the morning peak. However, it is expected to have 30.4% decline in travel time delay during the morning peak in 2028 compared to the baseline according to The Congestion Question Technical Report (2020).

Figure 29: Response to congestion charge - Trips to work or education



Source: Covec & MRCagney (2018).

Figure 30: Response to congestion charge - Other trips



Source: Covec & MRCagney (2018).

Gross cost effects per household

Figure 31 shows the distribution of baseline costs for morning peak travel in Auckland before the congestion charging scheme by household types and income levels. Note that the existing cost burden for morning peak travel is much less sensitive to income level than it is to household size and whether the household owns at least one vehicle. This is important context for the comparisons of added cost burden between income groups that follow: low income households pay nearly as much for transport as high income households, and this is consistent across household types.

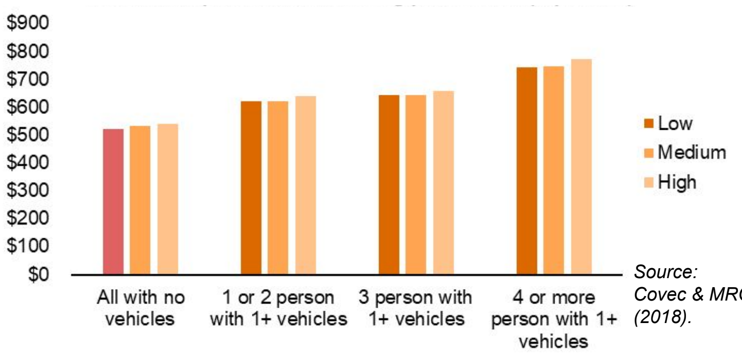
Figure 32 shows the gross change in dollars for trip costs with the congestion charge in place. These costs include the adjustments discussed above for mode-shift, trip suppression, route adjustment, etc. The gross costs are again more similar across income levels than they are across household types, although income appears to become more of a factor as households get larger. Note the totals for trips to work or education are shown separately from totals for other trips, so the full annual cost would be the sum of the two bars for each income and household group.

Comparing the two charts shows relatively greater variation by income for the gross change under the scheme than for the baseline costs. This arises from the demand responses described above, meaning households with lower income are more willing to change their travel patterns to avoid additional charges than households with higher incomes.

The cost per person calculated in the two figures on the right is based on the assumption of the household size under each household types:

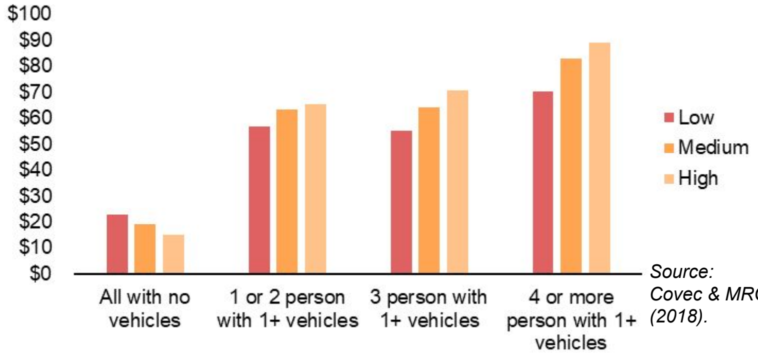
- **All with no vehicles**: 2 people per household
- **1 or 2 person with 1+ vehicles**: 1.5 people per household
- **3 person with 1+ vehicles**: 3 people per household
- **4 or more person with 1+ vehicles**: 5 people per household

Figure 31: Baseline trip costs for morning peak travel ($/person/year)



Source: Covec & MRCagney (2018).

Figure 32: Gross change in trip costs for morning peak travel ($/person/year)



Source: Covec & MRCagney (2018).

Relative cost effects per household

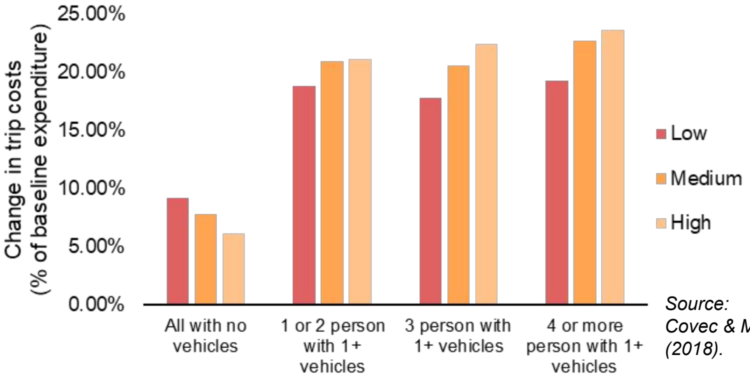
The figures to the right show the distribution of costs of the congestion charging scheme by household types and income levels. These are shown in two ways. Figure 33 shows the change in costs relative to the baseline trip costs for morning peak travel. Comparison with the above analysis shows car-owning households to be close to unit-elastic, meaning their cost effects and usage responses have similar magnitude compared to baseline levels. From this perspective, the charge can be described as progressive, meaning that higher income households pay more as a proportion of their baseline travel costs than lower income households do. For households with at least one vehicle, low income households pay around 10% of their existing baseline expenditure for morning peak travel (not 10% of total travel expenditure) regardless of household size.

This progressive pattern is consistent across household types, with the exception of households with no vehicles. This is likely due to differences in existing travel patterns between income groups for those households. For example, low-income households without a vehicle may be more reliant on peak-hour rideshare services than high-income households without a vehicle, which would expose them to the congestion charge.

Figure 34 shows the same change in costs relative to the mean household income for each group, which is broadly comparable to our disposable income parity measure. From this perspective, the charge appears regressive. Low income households pay a far higher proportion of their income for the scheme than high-income households. This is to be expected given that the gross costs do not vary significantly across income groups within each household type.

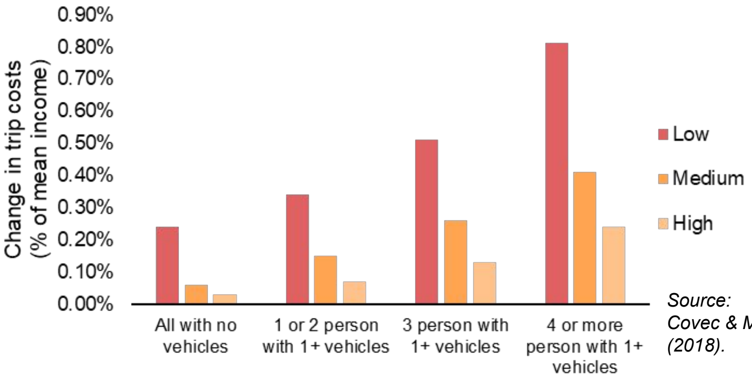
The contrast of these two perspectives provides a lesson about views of equity outcomes for new infrastructure charges under consideration. A focus on the charge itself relative to household income tells one story, while the broader context of expenditure on the infrastructure service in general tells a different one. In this case, the higher burden faced by low income households says more about the sector-wide distribution of costs and usage patterns in transport than does about the characteristics of the congestion charge itself.

Figure 33: Change in trip costs relative to baseline for morning peak travel



Source: Covec & MRCagney (2018).

Figure 34: Change in trip costs relative to income for morning peak travel



Source: Covec & MRCagney (2018).

Cost burden effects for alternative charging schemes

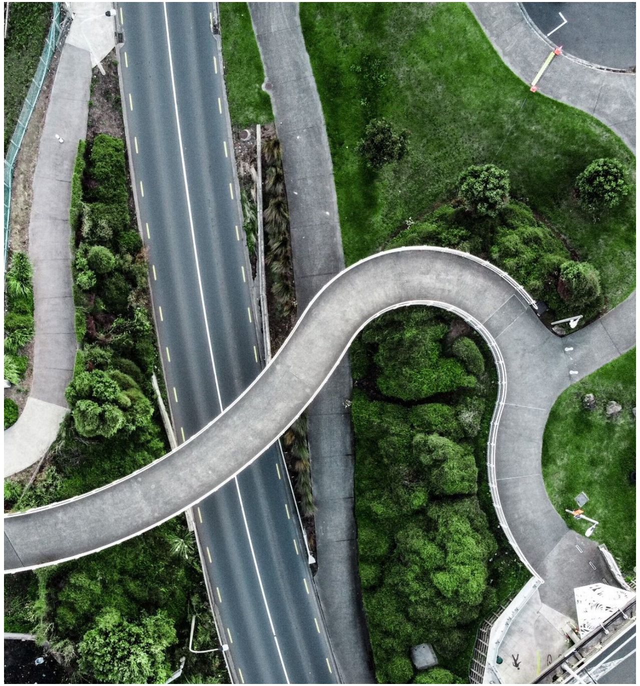
Overview

This section examines the distributions of cost burden that would occur under two alternative pricing mechanisms if they were to collect the same amount of revenue as the estimated collected revenue from the Strategic Corridors congestion charge described above. We do not consider second-order price elasticity effects.

Key assumptions are as follows:

- The fixed expenditures in the HES data reflect the annualised cost to own a basic vehicle, as a proxy for the cost of access to the network. Variations in household spending on this category will reflect variations in car ownership rates rather than the price-points of vehicles owned by these households. In our fixed-charge scenario, we use this as a basis for allocating fixed charges levied on a per-vehicle basis.
- Variable expenditures in the HES data largely reflect expenditure on transport fuels. We use this as a way to estimate the variation in usage based charges paid by households in our usage-based charge scenario.

While these two charging mechanisms could raise the same revenue as a congestion charge, they would both be ineffective at the primary purpose of congestion charging - to encourage more efficient use of the transport network by rewarding users for efficient behaviour and charging for inefficient behaviour. Since network congestion is acute in both time and location, a pricing mechanism must also be based on time and location of use in order to influence behaviour in the desired way.



Results for transport charges by income and geography

The figures below compare the distribution of costs for a fixed per-vehicle charge vs a variable charge based on fuel consumption. In both cases, the charge amounts are estimated based on the observed fixed and variable expenditures on transportation for each group from the HES. Charges are shown both as actual costs per person for each household and as disposable income parity equivalents.

Comparing the two mechanisms, we see much less variation for the fixed charge, whether across income groups or geographies. All households, regardless of income or geography, pay roughly between $15 and $21 per person based on their existing fixed private vehicle charges. This reflects that vehicle ownership rates are similar across these groups.

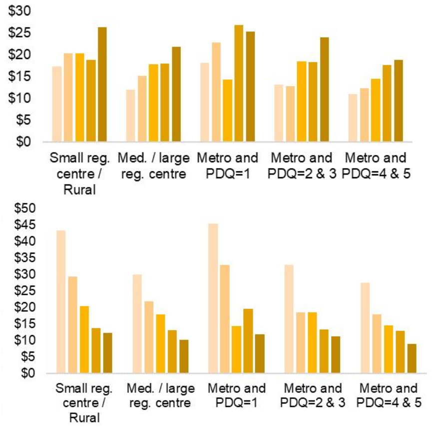
Compared to the variation in actual dollar charges, DIP costs show a far more severe range, meaning the range of difference for the charge is much narrower than the range of difference for incomes. This is consistent across geographies.

Under a variable charge that generates the same amount of revenue, the overall levels of expenditure across geographies are still similar. However, Households located in more densely populated areas seem to face slightly lower costs on average. This likely reflects shorter trip distances and greater accessibility via alternatives to private vehicle travel.

Variation across income groups is noticeably inconsistent between geographies. Usage seems to align most closely with income in the dense metro areas and medium and large regional centres. At the opposite extreme, the metro fringe shows the middle income group driving the least per person by a significant margin. These patterns likely reflect that levels of accessibility by alternative transport modes vary quite a bit within these geographic categories, particularly further away from urban centres. At higher incomes, high usage per person might indicate a preference for private vehicle travel. At lower incomes, it may indicate a lack of options.

Figure 35: Fixed per private vehicle charge

Figure 36: Variable private vehicle usage charge



Results for transport charges by income and household size

Comparison of the two mechanisms by household size shows that larger households pay less per person regardless of the pricing mechanism. This is intuitive. Large households can economise usage of a vehicle more effectively than smaller households.

Without the geographic distinctions, the charges appear more consistently progressive for both mechanisms and regardless of household size, whereas the fixed charge was closer to flat across income groups in the geographic view above.

Variation in costs by income groups is more pronounced for the variable charge than the fixed charge, reflecting the income elasticity of demand for travel vs demand for vehicles. Low income households may be able to minimise travel to save money, but it is more difficult to avoid owning a vehicle altogether.

Another implication of this is that the variable charge is more progressive than the fixed charge. Higher income households are choosing to use more and pay more while lower income households are choosing to use less and pay less than they would under the fixed charge. This holds for both household size categories.

This difference in responsiveness to the two mechanisms is the most relevant insight for understanding the equity implications of a fixed vs a usage-based charge, whether in transport or in other sectors. Pricing by usage allows households to have more control over how much they pay for infrastructure services.

Figure 37: Fixed per vehicle charge

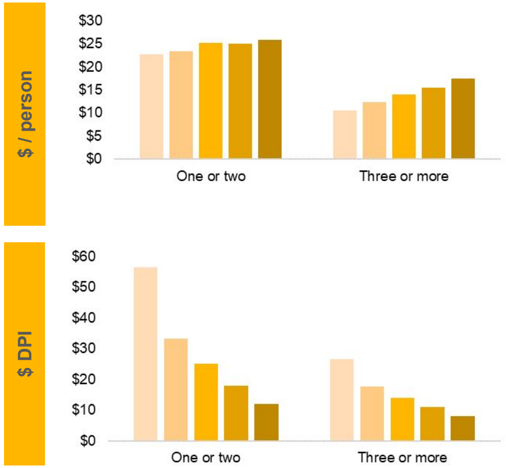
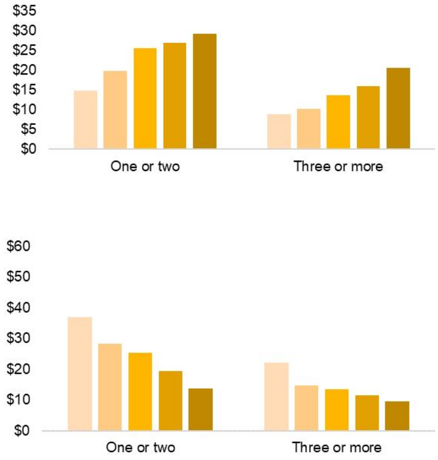


Figure 38: Variable per vehicle charge



A

Appendices

Appendix A: Restrictions

This document has been prepared for and only for Te Waihanga in accordance with the Consultancy Services Order dated 16 January 2023.

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Appendix B: Key assumptions (1 of 3)

In order to analyse the equity effects of the cost of water and telco for households under different pricing mechanisms, assumptions around usage and price sensitivity were made. The assumptions for water usage used in this analysis are outlined below.

Water:

- An average water usage based on household geography was assigned using the average daily usage per person for a proxy water entity. For the five categories of household geography the average water usage was assigned based on a water utility provider in a region where average population densities approximate the household geography category. Table B1 shows the water entities assigned to the differing household geography groups.
- The average water use was then adjusted for differing income groups using a multiplier for each income quintile. The middle income group received a multiplier of 1. Based on estimations of income elasticity in the literature, it was assumed a higher income group would use relatively more water then a lower income group, but that this difference will be proportionately less than the difference in income. A household size elasticity of water demand was also used, this assumed that households with more occupants would use more water then smaller households. The multipliers used are displayed in table B3 and the relevant elasticities are in table B2.

Table B1: Proxy water entities (2021 usage levels)

Household geography	Water entity	Avg. daily usage per person (L)
Small reg. centre / Rural	Kaipara	321
Med. / large reg. centre	New Plymouth	282
Metro and PDQ=1	Tauranga	168
Metro and PDQ=2 & 3	Hamilton	187
Metro and PDQ=4 & 5	Wellington Water	263

Source: Water New Zealand.

Table B2: Elasticity assumptions

Elasticity	Source
Income elasticity of water demand = 0.25	*National Infrastructure Commission (UK). 2017. Economic growth and demand for infrastructure services.*
Household size elasticity of water demand = 0.48	*Sebri, Maamar. 2013. A meta-analysis of residential water demand studies.*

Table B3: Water usage by income multipliers

Income group	Water usage multiplier
1	0.85
2	0.92
3	1
4	1.09
5	1.32

Table B4: Water usage by household size - example multipliers

Household size	Difference vs mean HH size	HH usage multiplier at 0.48 elasticity
1	-63.4%	0.695
2	-29.6%	0.871
3	9.7%	1.046
4	46.2%	1.222
5	82.8%	1.397

Appendix B: Key assumptions (2 of 3)

The assumptions for telco used in this analysis are outlined below.

Telco:

- In order to obtain an average telco usage in GBs per household, assumptions had to be made for both mobile usage and fibre usage. Because mobile coverage varies less by geography than fibre coverage, variation in mobile data usage was assigned based on income group. It was assumed that higher income households would have a higher mobile usage than lower income households as higher income households would be more willing to purchase higher cost plans with higher limits or unlimited data usage. The assigned average monthly mobile usage values for each income group are shown in table B5.
- A home broadband plan and associated assumption for average usage was assigned based on both income group and household geography. There were ten home broadband plans available in NZ at the time of collection for our HES data, all with varying average data usages. Households with a low density geography were assigned plans with low speeds and usages due to limited accessibility. Low income households were also assigned plans with a lower usage and cost. A combination of these two factors was then used to determine each household's expected fibre usage. The breakdown of these categories and how they were assigned is shown overleaf.
- A household's expected fibre and mobile usage were then combined to derive a total telco usage for each household in our analysis.

Table B5: Monthly mobile usage by income group

Income group	Mobile usage (GB)
1	0.8
2	2.5
3	6
4	8.5
5	18

Table B6: Fibre plans and usage

Fibre plan	Estimated monthly usage per person (GB)
ADSL (Copper)	50
WISP Fixed wireless	55
4G Fixed wireless	65
VDSL (Copper)	80
Low Earth Orbit Satellite	125
Fibre 100	127
5G Fixed wireless (lightweight)	290
5G Fixed wireless (standard)	550
HFC Max (Cable)	734
Fibre Max	833

Appendix B: Key assumptions (3 of 3)

Table B7: Assigned fibre usage based on household income and geography

Income group	Household geography	Fibre plan assumption	Expected fibre usage (GB)
1	Small reg. centre / Rural	ADSL (Copper)	50
2	Small reg. centre / Rural	ADSL (Copper), VDSL (Copper)	65
3	Small reg. centre / Rural	WISP Fixed wireless	55
4	Small reg. centre / Rural	WISP Fixed wireless, VDSL (Copper)	68
5	Small reg. centre / Rural	Low Earth Orbit Satellite	125
1	Med. / large reg. centre	WISP Fixed wireless, 4G Fixed wireless	60
2	Med. / large reg. centre	4G Fixed wireless, VDSL (Copper)	73
3	Med. / large reg. centre	VDSL (Copper), Fibre 100	104
4	Med. / large reg. centre	Fibre 100	127
5	Med. / large reg. centre	Fibre 100	127
1	Metro and PDQ=1	VDSL (Copper)	80
2	Metro and PDQ=1	VDSL (Copper), Fibre 100	104
3	Metro and PDQ=1	Fibre 100	127
4	Metro and PDQ=1	Fibre 100, Fibre Max	480
5	Metro and PDQ=1	Fibre 100, Fibre Max	480
1	Metro and PDQ=2 & 3	VDSL (Copper)	80
2	Metro and PDQ=2 & 3	VDSL (Copper), Fibre 100	104
3	Metro and PDQ=2 & 3	VDSL (Copper), Fibre 100	104
4	Metro and PDQ=2 & 3	Fibre 100, Fibre Max	480
5	Metro and PDQ=2 & 3	Fibre 100, Fibre Max	480
1	Metro and PDQ=4 & 5	VDSL (Copper)	80
2	Metro and PDQ=4 & 5	VDSL (Copper), Fibre 100	104
3	Metro and PDQ=4 & 5	HFC Max (Cable)	734
4	Metro and PDQ=4 & 5	HFC Max (Cable), Fibre Max	784
5	Metro and PDQ=4 & 5	Fibre Max	833

Appendix C: Modelled results tables (1 of 9)

Table C1: water charge ($/person) by income and geography

Pricing mechanism	Income group	Small reg. centre / Rural	Med. / large reg. centre	Metro and PDQ=1	Metro and PDQ=2 & 3	Metro and PDQ=4 & 5
Uniform annual charge	1	$969.67	$1,008.59	$812.81	$1,093.32	$885.75
	2	$688.24	$676.10	$682.36	$663.56	$598.83
	3	$520.91	$536.68	$545.89	$574.62	$525.60
	4	$481.06	$488.79	$484.83	$498.81	$472.69
	5	$478.21	$440.76	$449.00	$449.36	$424.60
Single volumetric charge	1	$425.92	$369.65	$223.50	$224.37	$374.08
	2	$531.30	$470.91	$260.57	$316.33	$474.17
	3	$656.14	$572.05	$328.28	$366.29	$538.55
	4	$741.22	$642.89	$385.45	$419.15	$608.92
	5	$900.61	$816.20	$472.06	$534.91	$771.22
Blended fixed and volumetric charge	1	$503.90	$461.27	$307.98	$348.92	$447.46
	2	$553.87	$500.38	$321.05	$366.13	$492.11
	3	$636.86	$567.07	$359.51	$396.20	$536.78
	4	$704.05	$620.91	$399.75	$430.63	$589.49
	5	$840.22	$762.53	$468.83	$522.74	$721.67
Increasing block tariff	1	$379.54	$315.15	$173.22	$150.22	$330.43
	2	$517.94	$453.43	$224.58	$286.71	$463.56
	3	$667.72	$575.10	$309.72	$348.53	$539.69
	4	$763.47	$656.09	$376.99	$412.38	$620.59
	5	$936.72	$848.29	$474.05	$542.25	$800.85

Appendix C: Modelled results tables (2 of 9)

Table C2: water charge ($DPI) by income and geography

Pricing mechanism	Income group	Small reg. centre / Rural	Med. / large reg. centre	Metro and PDQ=1	Metro and PDQ=2 & 3	Metro and PDQ=4 & 5
Uniform annual charge	1	$2,418.33	$2,515.41	$2,027.13	$2,726.73	$2,209.05
	2	$986.50	$969.09	$978.06	$951.13	$858.34
	3	$520.91	$536.68	$545.89	$574.62	$525.60
	4	$347.80	$353.39	$350.53	$360.63	$341.75
	5	$223.54	$206.04	$209.89	$210.06	$198.48
Single volumetric charge	1	$1,062.24	$921.91	$557.41	$559.58	$932.95
	2	$761.55	$674.98	$373.49	$453.41	$679.66
	3	$656.14	$572.05	$328.28	$366.29	$538.55
	4	$535.89	$464.80	$278.67	$303.04	$440.24
	5	$421.00	$381.54	$220.67	$250.05	$360.51
Blended fixed and volumetric charge	1	$1,256.72	$1,150.39	$768.09	$870.20	$1,115.95
	2	$793.90	$717.23	$460.18	$524.80	$705.37
	3	$636.86	$567.07	$359.51	$396.20	$536.78
	4	$509.02	$448.91	$289.01	$311.34	$426.19
	5	$392.77	$356.45	$219.16	$244.36	$337.35
Increasing block tariff	1	$946.56	$785.97	$432.00	$374.65	$824.10
	2	$742.40	$649.92	$321.91	$410.96	$664.45
	3	$667.72	$575.10	$309.72	$348.53	$539.69
	4	$551.97	$474.34	$272.56	$298.14	$448.67
	5	$437.88	$396.54	$221.60	$253.48	$374.36

Appendix C: Modelled results tables (3 of 9)

Table C3: water charge by income and household size

		$/person		$DPI	
Pricing mechanism	Income group	One or two	Three or more	One or two	Three or more
Uniform annual charge	1	$1,167.47	$425.76	$2,911.65	$1,061.83
	2	$919.42	$399.26	$1,317.87	$572.29
	3	$889.46	$395.25	$889.46	$395.25
	4	$815.04	$389.23	$589.26	$281.41
	5	$793.86	$374.80	$371.10	$175.21
Single volumetric charge	1	$337.28	$507.72	$841.16	$1,266.24
	2	$372.90	$539.29	$534.50	$773.00
	3	$392.34	$580.26	$392.34	$580.26
	4	$436.61	$623.39	$315.66	$450.70
	5	$521.11	$741.60	$243.60	$346.67
Blended fixed and volumetric charge	1	$456.29	$496.05	$1,137.98	$1,237.14
	2	$451.27	$519.31	$646.84	$744.36
	3	$463.64	$553.84	$463.64	$553.84
	4	$490.91	$589.93	$354.92	$426.51
	5	$560.27	$689.15	$261.91	$322.15
Increasing block tariff	1	$266.44	$514.74	$664.50	$1,283.76
	2	$326.28	$551.28	$467.68	$790.18
	3	$349.94	$596.08	$349.94	$596.08
	4	$404.34	$643.41	$292.33	$465.17
	5	$497.86	$772.95	$232.73	$361.32

Appendix C: Modelled results tables (4 of 9)

Table C4: telco charge ($/person) by income and geography

Pricing mechanism	Income group	Small reg. centre / Rural	Med. / large reg. centre	Metro and PDQ=1	Metro and PDQ=2 & 3	Metro and PDQ=4 & 5
Uniform annual charge	1	$2,368.21	$2,463.29	$1,985.12	$2,670.22	$2,163.27
	2	$1,680.89	$1,651.23	$1,666.52	$1,620.62	$1,462.53
	3	$1,272.21	$1,310.72	$1,333.22	$1,403.38	$1,283.67
	4	$1,174.90	$1,193.77	$1,184.11	$1,218.25	$1,154.45
	5	$1,167.93	$1,076.46	$1,096.60	$1,097.46	$1,037.00
Single volumetric charge	1	$371.30	$461.17	$494.84	$662.46	$538.43
	2	$362.80	$394.78	$556.16	$541.63	$491.59
	3	$282.79	$483.68	$586.61	$513.01	$2,950.27
	4	$340.00	$561.12	$1,835.66	$1,885.77	$2,863.65
	5	$652.88	$624.50	$1,816.15	$1,817.41	$2,848.13
Usage-cap tariffs	1	$1,441.51	$1,401.93	$1,258.34	$1,126.51	$771.92
	2	$1,102.90	$954.31	$875.91	$1,232.78	$591.60
	3	$621.45	$761.76	$923.87	$552.95	$2,763.18
	4	$864.59	$675.27	$1,978.58	$1,795.79	$2,322.45
	5	$785.70	$584.89	$1,729.48	$1,473.94	$1,907.50

Appendix C: Modelled results tables (5 of 9)

Table C5: telco charge ($DPI) by income and geography

Pricing mechanism	Income group	Small reg. centre / Rural	Med. / large reg. centre	Metro and PDQ=1	Metro and PDQ=2 & 3	Metro and PDQ=4 & 5
Uniform annual charge	1	$5,906.27	$6,143.39	$4,950.85	$6,659.47	$5,395.15
	2	$2,409.32	$2,366.81	$2,388.72	$2,322.93	$2,096.33
	3	$1,272.21	$1,310.72	$1,333.22	$1,403.38	$1,283.67
	4	$849.43	$863.08	$856.09	$880.77	$834.65
	5	$545.96	$503.20	$512.62	$513.02	$484.75
Single volumetric charge	1	$926.01	$1,150.14	$1,234.13	$1,652.16	$1,342.83
	2	$520.02	$565.86	$797.18	$776.35	$704.63
	3	$282.79	$483.68	$586.61	$513.01	$2,950.27
	4	$245.82	$405.68	$1,327.15	$1,363.38	$2,070.37
	5	$305.19	$291.93	$848.97	$849.57	$1,331.38
Usage-cap tariffs	1	$3,595.10	$3,496.39	$3,138.28	$2,809.49	$1,925.16
	2	$1,580.85	$1,367.87	$1,255.50	$1,767.02	$847.97
	3	$621.45	$761.76	$923.87	$552.95	$2,763.18
	4	$625.09	$488.21	$1,430.48	$1,298.32	$1,679.09
	5	$367.28	$273.41	$808.46	$689.00	$891.68

Appendix C: Modelled results tables (6 of 9)

Table C6: telco charge by income and household size

		$/person		$DPI	
Pricing mechanism	Income group	One or two	Three or more	One or two	Three or more
Uniform annual charge	1	$2,851.31	$1,039.82	$7,111.11	$2,593.30
	2	$2,245.50	$975.11	$3,218.62	$1,397.69
	3	$2,172.32	$965.32	$2,172.32	$965.32
	4	$1,990.56	$950.62	$1,439.14	$687.28
	5	$1,938.85	$915.38	$906.33	$427.90
Single volumetric charge	1	$565.81	$223.10	$1,411.12	$556.41
	2	$606.14	$293.60	$868.81	$420.83
	3	$2,015.22	$1,052.47	$2,015.22	$1,052.47
	4	$2,669.99	$1,471.68	$1,930.36	$1,064.00
	5	$3,050.72	$1,743.65	$1,426.09	$815.08
Usage-cap tariffs	1	$1,446.10	$507.07	$3,606.53	$1,264.62
	2	$1,285.29	$556.13	$1,842.28	$797.14
	3	$2,154.76	$1,114.42	$2,154.76	$1,114.42
	4	$2,530.67	$1,363.23	$1,829.63	$985.59
	5	$2,340.56	$1,307.91	$1,094.12	$611.40

Appendix C: Modelled results tables (7 of 9)

Table C7: transport charge ($/person) by income and geography

Pricing mechanism	Income group	Small reg. centre / Rural	Med. / large reg. centre	Metro and PDQ=1	Metro and PDQ=2 & 3	Metro and PDQ=4 & 5
Fixed charge	1	$20.39	$20.56	$19.12	$21.18	$17.07
	2	$18.22	$18.27	$19.70	$18.45	$16.46
	3	$16.89	$17.62	$16.35	$18.69	$16.40
	4	$15.29	$17.80	$18.29	$17.95	$18.00
	5	$18.64	$17.92	$17.98	$19.27	$18.88
Variable charge	1	$17.30	$12.02	$18.19	$13.18	$10.97
	2	$20.36	$15.17	$22.90	$12.84	$12.37
	3	$20.32	$17.82	$14.35	$18.48	$14.55
	4	$18.88	$17.92	$26.89	$18.28	$17.59
	5	$26.29	$21.83	$25.32	$24.03	$18.88

Appendix C: Modelled results tables (8 of 9)

Table C8: transport charge ($DPI) by income and geography

Pricing mechanism	Income group	Small reg. centre / Rural	Med. / large reg. centre	Metro and PDQ=1	Metro and PDQ=2 & 3	Metro and PDQ=4 & 5
Fixed charge	1	$50.86	$51.29	$47.69	$52.82	$42.57
	2	$26.11	$26.19	$28.23	$26.44	$23.59
	3	$16.89	$17.62	$16.35	$18.69	$16.40
	4	$11.05	$12.87	$13.22	$12.98	$13.01
	5	$8.71	$8.38	$8.41	$9.01	$8.83
Variable charge	1	$43.14	$29.98	$45.37	$32.88	$27.36
	2	$29.18	$21.74	$32.83	$18.40	$17.73
	3	$20.32	$17.82	$14.35	$18.48	$14.55
	4	$13.65	$12.96	$19.44	$13.22	$12.72
	5	$12.29	$10.20	$11.84	$11.23	$8.83

Appendix C: Modelled results tables (9 of 9)

Table C9: transport charge by income and household size

		$/person		$DPI	
Pricing mechanism	Income group	One or two	Three or more	One or two	Three or more
Fixed charge	1	$22.71	$10.64	$56.63	$26.53
	2	$23.29	$12.43	$33.39	$17.82
	3	$25.20	$13.96	$25.20	$13.96
	4	$25.02	$15.47	$18.09	$11.18
	5	$25.76	$17.42	$12.04	$8.14
Variable charge	1	$14.82	$8.93	$36.96	$22.26
	2	$19.81	$10.30	$28.39	$14.76
	3	$25.46	$13.68	$25.46	$13.68
	4	$26.97	$16.05	$19.50	$11.61
	5	$29.28	$20.47	$13.69	$9.57

Appendix D - References

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Ngā mihi nui