NEW ZEALAND
INFRASTRUCTURE
COMMISSION
*Te Waihanga*

# How much do we pay for infrastructure?

## Household expenditure on infrastructure services

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# New Zealand Infrastructure commission / Te Waihanga

Te Waihanga seeks to transform infrastructure for all New Zealanders. By doing so our goal is to lift the economic performance of Aotearoa and improve the wellbeing of all New Zealanders.

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# Cut to the chase

High quality, affordable infrastructure is vital to our quality of life and to the functioning of our economy. Safe transport, reliable electricity, extensive mobile phone coverage, fast internet services, and clean water underpin our modern standards of living.

Infrastructure is not free. Significant resources are needed to build infrastructure, maintain it, and replace it when it wears out. All New Zealand households contribute to the costs of providing infrastructure services. However, we do not have comprehensive information on how much they pay and how those costs are distributed between households.

This paper improves our understanding of household spending on infrastructure services. It covers land transport (roading and public transport), energy (electricity, gas, and heating fuels), water (drinking, storm, and waste), and telecommunications (mobile and fixed-line).

The aim of the research is to understand how affordable infrastructure services are for different types of households. A key finding is that households that *look similar* can spend *very different amounts on infrastructure*. This reflects different decisions about how and when households use different infrastructure services. As a result, assessing the affordability of infrastructure services is more complex and nuanced than simply comparing average spending for households with similar income or demographic characteristics. This diversity of experience also means that it can be challenging to effectively target assistance to those in need.

## What we include in expenditure estimates

Our analysis uses data on household expenditure and incomes from Statistics NZ's Household Economic Survey (HES). We use data from five survey waves between 2006/07 and 2018/19. This records the actual amounts that surveyed households spent on purchases like electricity, petrol, or mobile phone services. We analyse HES data at the level of individual households to estimate spending on infrastructure services.

Our analysis accounts for the fact that households pay for infrastructure services in multiple ways. For example, maintenance and development of the road network is funded via user tolls, fuel excise duties, road user charges, and local body rates. We account for all of these funding mechanisms.

Our analysis also accounts for the fact that households incur 'access costs' to use some types of infrastructure. Examples include needing to own or rent a car to use the road network and needing to own a mobile phone to access the mobile telecommunications network. Where we include access costs, we have costed only a relatively 'basic' level such as the annual cost of owning a 'basic' car or mobile phone. While many households spend more on their vehicles, higher expenditure can be seen as a discretionary or 'luxury' expenditure.

## How much do households spend on infrastructure services?

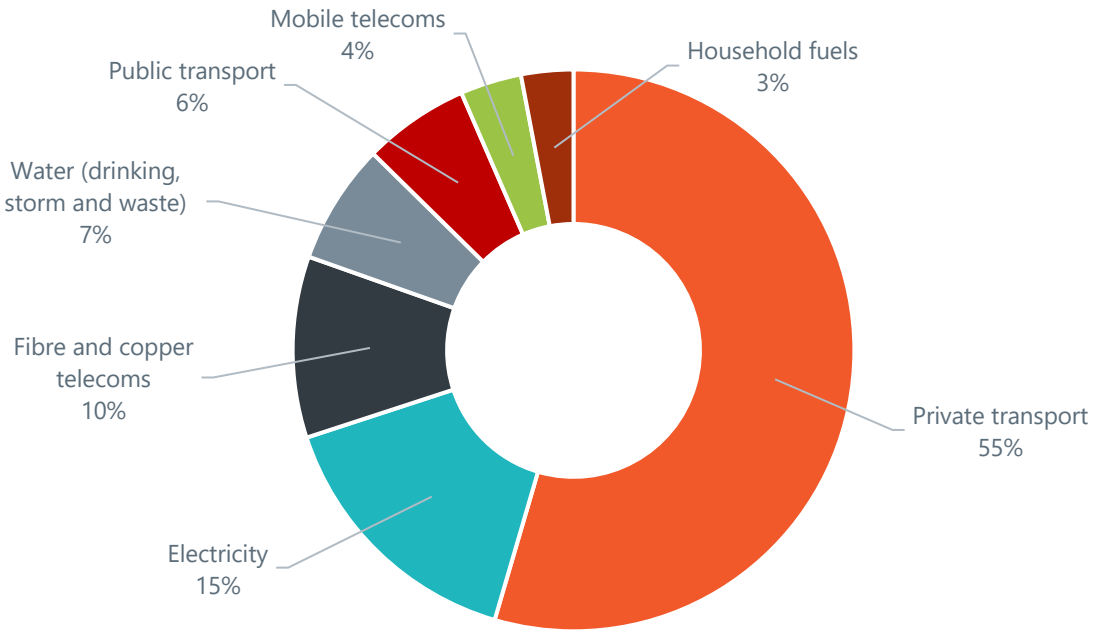
The average New Zealand household spent around 16% of its after-tax income on infrastructure services in 2018/19, which is the most recent year for which data is available. That is slightly over $13,500 per year, or around $260 per week.

Households' infrastructure spending has risen over time. After adjusting for inflation, the average household spent around $600 more on infrastructure in 2018/19 than they did in 2006/07. However, incomes have risen more rapidly, and as a result the share of after-tax income spent to infrastructure services has declined over time – it was over 19% in 2006/07.

Figure 1

shows the composition of household spending on infrastructure. Private transport is by far the largest component, at 55% of total infrastructure spending. That is followed by electricity (15%), telecommunications (14%), water (drinking, storm, and waste) (7%), and public transport (3%).

Figure 1: Breakdown of New Zealand households' infrastructure spending, averaged over 2006/07 to 2018/19 survey waves




## Higher-income households spend more on infrastructure, in total...

Because higher-income households have more money available to spend, they tend to spend more on goods and services in general. Infrastructure services follow that pattern.

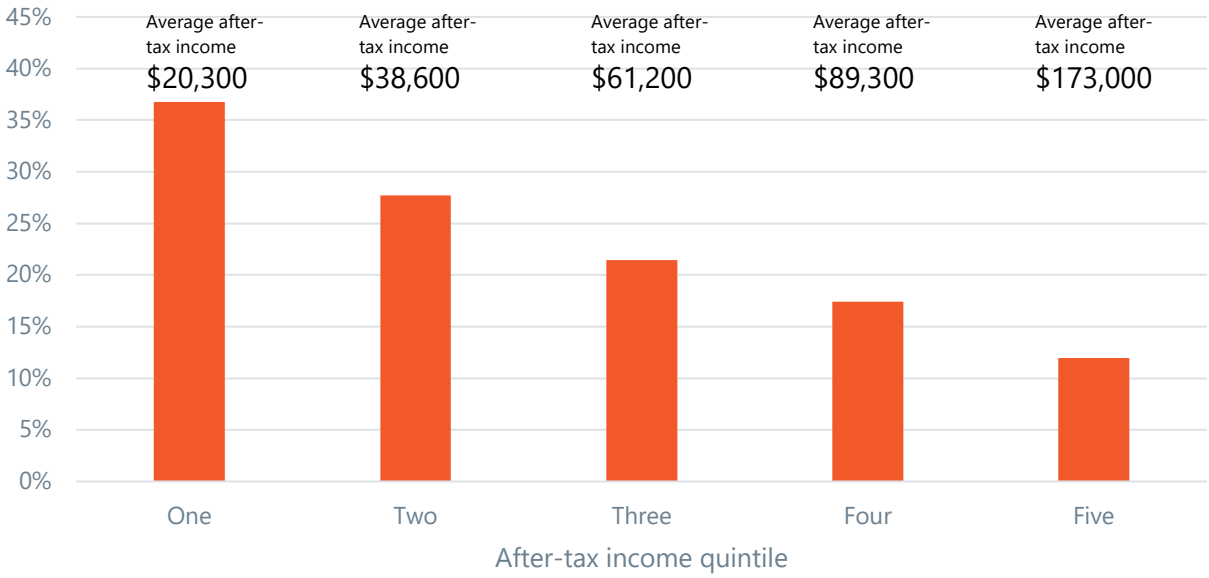
We divided the households in our study into five quintiles based on their after-tax household income. The average household in the highest income quintile spent around $20,600 per year on infrastructure services, while the average household in the lowest income quintile spent around $7,400 per year.

## ... but they tend to spend a smaller share of their income

While households spend more on infrastructure services as their income increases, their spending does not rise as quickly as does their income. On average, a 1% increase in household income is associated with a 0.24% increase in overall infrastructure spending.

Figure 2 shows that lower-income households tend to spend a larger share of their after-tax income on infrastructure services as a result. Households in the lowest income quintile spend 37% of their after-tax income on infrastructure, while households in the highest income quintile spend 12%.

Figure 2: Share of households' after-tax income spent on infrastructure services by after-tax income quintile (2006/07 to 2018/19)




## Infrastructure tends to be more affordable in cities

Household infrastructure spending varies considerably between different types of locations.

We categorise households into five groups: rural areas and small regional centres, medium to large regional centres, and low-density, medium density, and high-density areas of large cities.[1]

Both household incomes and infrastructure spending vary between these categories. In dollar terms, average infrastructure spending per household is highest in low-density areas on the fringe of large cities spend the most, at slightly over $18,500 per annum. Average incomes are also significantly higher in these locations. Infrastructure spending is lowest in medium to large regional centres like Timaru and Palmerston North, at slightly over $11,000 per annum.

Figure 3 shows the average share of household after-tax income spent on infrastructure services in different locations. Households living in large cities spend the smallest share of their incomes on infrastructure services (16.3% for low-density areas of large cities, 16.5% for medium-density areas, and 17.1% for high-density areas). Households living in medium and large regional centres spend slightly over 18% of after-tax income. Households living in rural areas small regional centres or rural areas spend the most, at slightly over 20% of after-tax income.

In part, this reflects different access to infrastructure networks. For instance, households in rural areas and small regional centres are less likely to have access to public transport, and sometimes face higher private transport costs due to longer travel distances to get to their places of work and leisure.

[1] We use Statistics New Zealand's functional urban area classifications, overlaid with data on population density.

Figure 3: Share of households' after-tax income spent on infrastructure services by location (average 2006/07 to 2018/19)


## Infrastructure tends to be more affordable for working households

In dollar terms, households with at least one working adult spend more on infrastructure services than households without working adults. Similarly, households with at least one dependent child tend to spend more on infrastructure services than households without children. This reflects different use of infrastructure services – working households need to spend more on commuting, while households with children typically need to spend more on travel and home heating.

However, working households tend to have higher after-tax incomes than non-working households, and households with children tend to have higher after-tax incomes than households without children.[2]

As a result, Figure 4 shows that working households tend to spend a smaller share of their after-tax income on infrastructure services than non-working households. For instance, working households with children spend around 17% of their income on infrastructure services, compared with 27% for non-working households with children. On average, having children results in a 1 percentage point increase in the share of household income spent on infrastructure services.

[2] Higher after-tax incomes for households with children are likely to reflect the impact of Working for Families tax credits and higher benefit payments for families with children.

Figure 4: Share of households' after-tax income spent on infrastructure services by household composition (2006/07 to 2018/19)


## There is more variation within groups than between groups

Because our analysis uses household-level data on spending, we can analyse differences in spending between individual households as well as differences in average spending between groups. We find that variation within groups of similar households is larger than variation between groups. Households that are fairly similar – in terms of income, location, and household composition – often spend very different amounts on infrastructure.

For example, the average household in the lowest income quintile spends around 37% of its income on infrastructure services, which might indicate challenges with the affordability of infrastructure services. However, many low-income households appear to face smaller affordability challenges. We estimate that one in six low-income households spend less than 10% of their income on infrastructure services – a lower ratio than the average household in the highest income quintile.

Similarly, while the average rural household spends around 20% of its income on infrastructure services, one in four rural households appear to spend more than 35% of their income on infrastructure services. This suggests that some, but not all, rural households may face difficulty affording infrastructure services.

This highlights that average infrastructure spending for a group of households is an unreliable indicator of infrastructure services affordability for each individual household within that group.

## Low-income households are not all alike

Because infrastructure spending varies so much within low-income households, we took a closer look at these households. We classified them into five categories – retiree households, beneficiary households, student households, working households, and other households – according to their primary source of income. We also looked at home ownership as a rough proxy for accumulated wealth.

We find that slightly more than half of low-income households (52%) were retiree households. The next largest group was households receiving more than half of their income from government benefits (23% of income quintile one), followed by working households (17%), and students (4%). While these

households share the common characteristic of having relatively low income, they are quite different in other ways.

While retirees generally have low incomes, they are more likely than other groups to own their own homes. University students currently have low incomes, but they can expect to earn higher incomes in the future after completing their education. It is not surprising that these groups spend an unusually large share of their present-day income on infrastructure services, as retirees with sufficient assets can spend down their savings while students can rely more heavily on debt.

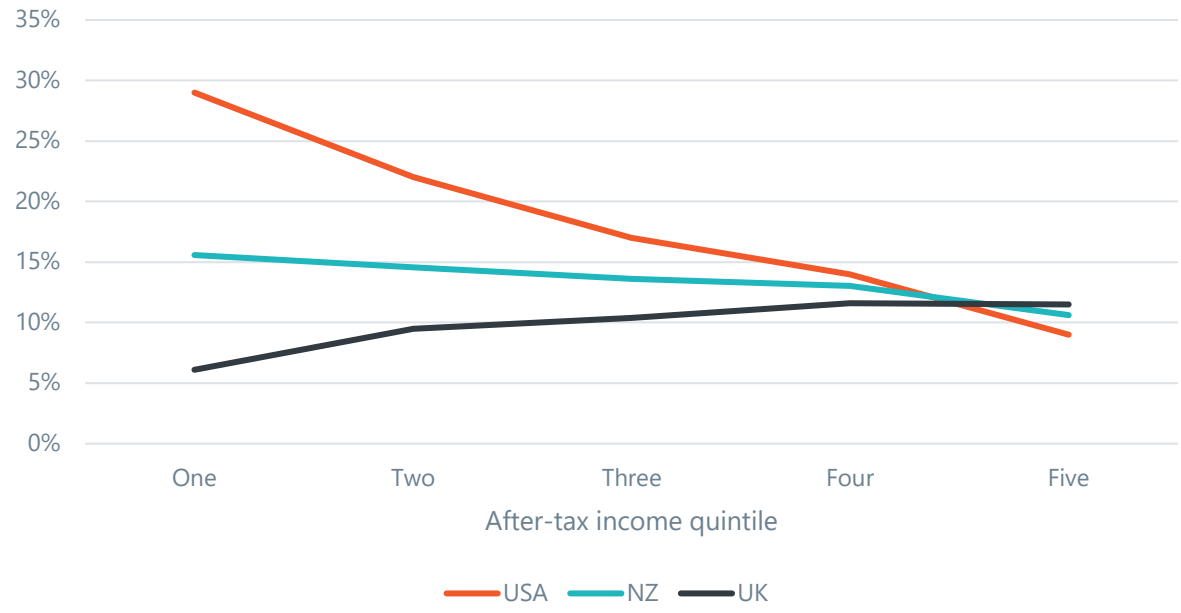
## Spending patterns vary between countries

We compared our findings on household infrastructure spending with similar analyses of household infrastructure spending in Australia, the United Kingdom, and the United States. These comparisons are challenging due to methodological differences between countries, and as a result we caution against drawing strong conclusions about those differences.

With that important caveat in mind, we find that patterns of household spending on infrastructure are broadly similar in New Zealand and Australia. Average households in both countries spend similar shares of their after-tax incomes on infrastructure services. Spending patterns across income quintiles are also similar.

Patterns of household spending on transport vary significantly between countries, potentially reflecting different approaches to providing and using transport infrastructure. Figure 5 shows the relationship between household income quintile and spending on transport services in New Zealand, the UK, and the US. In the US, low-income households spend a much larger share of their income on transport than high-income households. In the UK, the opposite pattern holds – high-income households spend a larger share of their income on transport. New Zealand is somewhere between those two countries.

Figure 5: Transport share of total household expenditure by after-tax income quintile in New Zealand, the United Kingdom, and the United States




*Note: United States and United Kingdom data includes actual vehicle purchase costs, while New Zealand data only includes annualised capital maintenance charge of $1,500 per year per car, which likely flattens the curve.*

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# List of acronyms

| | |
|---|---|
| CAPEX | Capital expenditure |
| CNG | Compressed natural gas |
| HEIS | Household expenditure on infrastructure services |
| HES | Household expenditure survey |
| IDI | Integrated data infrastructure |
| LCF | Living costs and food survey |
| LPG | Liquid petroleum gas |
| MBIE | Ministry of Business, Innovation and Employment |
| NLTF | National land transport fund |
| NZD | New Zealand dollar |
| OLS | Ordinary least squares |
| ONS | Office for National Statistics |
| OPEX | Operational expenditure |
| PDQ | Population density quintile |
| RC | Regional council |
| RUC | Road user charges |
| SA2 | Statistical Area 2 |
| SU | Synthetic unitary authority |
| TA | Territorial authority |
| UA | Unitary authority |
| WOF | Warrant of fitness |

# 1. Introduction

## 1.1. Infrastructure is not free.... someone has to pay

Infrastructure networks are vital to our quality of life, and the functioning of our economy. Safe transport, reliable electricity, extensive mobile phone coverage, fast internet services, and clean water underpin our modern standards of living.

Infrastructure is not free. Significant resources are needed to build infrastructure, maintain it, and replace it when it wears out. *Rautaki Hanganga o Aotearoa, the New Zealand Infrastructure Strategy 2022– 2052*[3] highlights the importance of infrastructure, that we have choices about how to pay those costs, including direct payments from users or indirect revenue from rates and taxes. Similarly, we can defer some, but not all, infrastructure costs to future generations by raising debt or delaying maintenance. But whatever choices we make, ultimately somebody must pay these costs if we want an extensive, modern, and sustainable infrastructure system.

Given all that, it is somewhat surprising that there are significant knowledge gaps about the use of infrastructure, the quality of service received, and the amount that New Zealanders are paying.

## 1.2. We want to understand what's fair ...

Te Waihanga is undertaking a 'deep dive' into the topic of what's fair when it comes to providing and paying for infrastructure. The deep dive is to understand the impacts of decisions about where infrastructure is provided, who benefits from it, and who pays for it. We want to form a judgement about what's fair in terms of infrastructure provision, funding, and pricing.

To inform that judgement we need to know how costs fall, for example, on users vs. non-users, across regions, between rural and urban dwellers, between current and future generations, and between people who can easily afford to pay and those who cannot.

## 1.3. ... so we need to know what people are currently spending ...

To help answer the question of what's fair, we need to understand what people currently spend on infrastructure services, and how that varies with their circumstances. The aim of this *Research Insights* paper is to investigate expenditure on four types of infrastructure services: land transport, energy, water, and telecommunications.

This paper uses data from New Zealand's Household Economic Survey (HES), which records the expenditure of households, rather than individuals. Consequently, the household is our unit of analysis. The paper addresses five main research questions:

- **How significant are infrastructure costs for households?** How much do households in New Zealand spend on infrastructure services, both in total and as a share of their after-tax income?
- **Do some types of households spend more than others?** How does spending on infrastructure services vary by household income, household composition, geographic location, and over time?

[3] Recommendation 56 in the Strategy highlights the need to improve public understanding of how infrastructure is priced in different infrastructure sectors, and the implications for equity and the quality of provision.

- **Do some individual households spend more than other similar households?** How much variation in infrastructure expenditure is there between individual households that are similar in terms of income, location, and composition?
- **How much does infrastructure spending change when incomes rise**? What is the income elasticity of household infrastructure spending, after controlling for other household characteristics like location and composition?
- **What is the demographic make-up, and what are the sources of income, of the lowest income households?** More generally, how do households vary by their source of income? How does this affect the relationship between after-tax income and infrastructure spending? [4]

## 1.4…. to better inform decision making

An improved understanding of what New Zealanders pay for their infrastructure will help decision makers to better assess the adequacy of current institutional and funding arrangements. It will also contribute to a better understanding of how affordable New Zealand's infrastructure is, and how fair current pricing arrangements are; and the extent to which the answers to those questions vary depending on people's personal circumstances, such as how much they earn and where they live.

This paper relies primarily on expenditure data, which, by itself reveals little about the quantity of services purchased or the quality received. However, this analysis does tell us about the fiscal incidence of infrastructure services on households, which is a crucial input into questions about the fairness of infrastructure services pricing.

[4] Appendix B addresses this fifth question.

# 2. What we can (and cannot) learn from expenditure surveys

Our analysis is based on data from the Household Economic Survey administered by Statistics New Zealand, which collects information on household income and housing costs on an annual basis and collects information on wealth and household spending every three years. For this research we use household-level income and expenditure data from the 2006/07, 2009/10, 2012/13, 2015/16, and 2018/19 survey years.

We use this data to calculate what people pay for infrastructure services. We account for the different ways that households pay for infrastructure networks, including via rates and general taxation, as well as what they spend on privately provided items like vehicles and mobile phones that are needed to access infrastructure networks.

This section briefly outlines our data sources and methodologies.

## 2.1. Data sources

Stats New Zealand's Household Economic Survey (HES) is conducted yearly, with approximately 15,000 respondents. This study draws on the expenditure module of the HES, which is fielded to a subset of respondents every three years. Five years of expenditure module data were available for this project.

Table 1 shows the number of household observations used in this project. The HES count column shows the original number of household responses before data exclusions, and the Household Expenditure on Infrastructure Services (HEIS) count column shows the actual number of household responses used for this project, after data exclusions.[5]

Table 1: Number of households included in each survey year

| Survey | HES count | Equivalent NZ households | HEIS count | Equivalent NZ households |
|---|---|---|---|---|
| 2006/07 | 2,901 | 1,561,000 | 2,802 | 1,500,000 |
| 2009/10 | 3,126 | 1,608,000 | 3,024 | 1,551,000 |
| 2012/13 | 3,003 | 1,641,000 | 2,934 | 1,596,000 |
| 2015/16 | 3,501 | 1,690,000 | 3,420 | 1,650,000 |
| 2018/19 | 3,933 | 1,758,000 | 3,825 | 1,700,000 |
| Total | 16,464 | | 16,005 | |

*Note: counts are randomly rounded to a multiple of 3, for example, a 5 would be displayed as either 3 or 6. The equivalent households are rounded to the nearest 1,000.*

## 2.2. Components of expenditure: E = P × Q + F – D

The HES, like other expenditure surveys, records how much the people in a household spent on specific goods and services.

[5] Households were excluded if we could not determine their geographic location, if their disposable income was zero or negative, or if their expenditure on infrastructure services was zero, negative, or exceeded their disposable income. 2.8% of households were excluded by these criteria. See the accompanying technical paper for full details.

The HES records expenditure (E) across a wide variety of purchase categories. In the latest survey year, the HES recorded a week of household expenditure, whereas the previous years recorded a fortnight of expenditure. We can decompose expenditure into four components, none of which are directly recorded in the HES:

- Price (P): the price the household paid per unit for the infrastructure service.
- Quantity (Q): the number of units of the infrastructure service purchased by the household.
- Fixed costs (F): the amount the household pays for access to the service, irrespective of the quantity purchased.
- Discounts (D): any discounts received (for example, quantity discounts or discounted bus fares for children).

Importantly, expenditure should not be interpreted as either price or quantity. Similarly, a change in expenditure should not be interpreted as a change in either price or quantity.

Price, quantity, fixed costs, and discounts are not recorded in the HES, but we are able to estimate or infer fixed costs for most infrastructure services based on data on infrastructure providers' charges and expenditures.

## 2.3. Direct and indirect expenses

Households pay directly for some infrastructure services, such as electricity, whereas others are paid for indirectly, buried inside other charges. For example, in most parts of New Zealand, water services are part of local council rates; they are not separately identified on rates bills, nor within the HES. Table 2 outlines how households pay for infrastructure services. We account for most indirect expenditure when estimating the fiscal incidence of infrastructure services across households. For renting households, we assume that landlords pass through the full cost of rates to tenants.

There is a limit to how far we can take fiscal incidence. For example, if a household engages a plumber to repair pipes at their house, that plumber also uses infrastructure services (for example, roads and telecommunications) to complete the repair. The cost of these services will be embedded in the plumber's bill. We do not include such embedded infrastructure costs in this study.

## 2.4. Access costs

Our starting point was to take a comprehensive view of infrastructure expenditure. We also anticipated wanting to compare across different infrastructure types, such as transport and electricity. Therefore, we wanted an approach that would allow us to make consistent comparisons.

However, it is difficult to be consistent. One issue is with what we term 'access charges'. These are the private costs a household incurs to be able to make use of an infrastructure service. This varies from zero for public transport, to needing a working vehicle to use roads.

Table 3 outlines our treatment of access costs. While there are some grey areas, we believe the decisions made to be individually justified and we have documented them here on that basis.

Table 2: How households pay for infrastructure services

| Infrastructure type | Specific service | Paid via general taxation | Paid via RC/TA[6] rates | Paid via user charges, as recorded in HES | |
|---|---|---|---|---|---|
| | | | | Fixed costs | Variable costs |
| Roading | Private transport | Central government contributions to NLTF[7], less non-road expenditure | TA spending on roads | Driver's license, vehicle registration, WOF, vehicle insurance, vehicle costs | Petrol, diesel, RUC[8], tolls, parking[9] |
| Public transport | Bus and rail (commuter services)[10] | Central government and NLTF contributions | RC subsidies | None | Fares |
| Water | Drinking water | None | TA spending | None | None[11] |
| | Wastewater | | | | |
| | Stormwater | | | | |
| Telecoms | Fixed line (fibre and/or copper) | None | None | Service charges, equipment | Bills |
| | Mobile (calls and/or data) | | | Equipment purchase (such as cell phones) | Telecom bills |
| Electricity | Household power | None | None | Electricity service charges | Electricity unit charges |
| Gas | Reticulated household gas | None | None | Reticulated gas service charges | Gas unit charges |
| Other heating fuels[12] | Home heating fuels | None | None | None | Heating oil, firewood, CNG, LPG and coal |

[6] RC = regional council and TA = territorial authority. Some TAs are also RCs, these are known as unitary authorities (UA). We aggregate non-UA TAs into synthetic unitary authorities (SU).
[7] NLTF = national land transport fund. This is an intermediary fund that takes money from multiple sources, the largest of which is petrol taxes, and redistributes it, primarily to the New Zealand Transport Authority for state highways, TAs for local roads, and RCs for public transport.
[8] RUC = road user charges. In this context, paid by the owners of diesel-powered vehicles as an alternative to petrol tax.
[9] Electric vehicle charging is not recorded in the 2018/19 HES expenditure module, nor any of the earlier surveys.
[10] We do not explicitly account for the fact that buses use roads.
[11] Some councils have volumetric charging for water (drinking and/or wastewater). Most do not. For those that do, water charges are not consistently separated out the HES data. Therefore, we apply an imputation method for water charges for all households.
[12] Other heating fuels are included to avoid an unbalanced expenditure picture of households that do not use electricity or gas for heating and cooking. In this report we combine reticulated household gas and other household heating fuels into one category named heating fuels.

Table 3: Included and excluded infrastructure service access costs

| Infrastructure service | Included in access costs | Excluded from access costs |
|---|---|---|
| Private transport | Annualised vehicle capital cost[13], vehicle maintenance and repair, licensing, registration, WOF | Vehicle purchase, towed vehicles (for example, caravans, trailers), bicycles, scooters, garages |
| Bus and rail (commuter services) | | |
| Drinking water | | Connection costs and private supply (for example, tanks) |
| Wastewater | | Connection costs and private supply (for example, septic tanks) |
| Stormwater | | Connection costs and private infrastructure |
| Fixed line (fibre and/or copper) | Installation and repair to where the service terminates at dwelling | Appliances and over-the-top services (for example, Netflix) |
| Mobile (calls and/or data) | Phone purchase[14] and repair | Tablets and other accessories |
| Household electricity | Installation and repair to where the service terminates at dwelling | Appliances |
| Reticulated household gas | Installation and repair to where the service terminates at dwelling | Cooking and heating appliances |
| Home heating fuels | None | Heaters, fireboxes, and fuel storage |

[13] For vehicle purchase, we estimate the number of vehicles in the household, and then charge these at $1500/annum (Inflation adjusted to quarter one 2019 NZD), which is the annualised cost of ownership for a basic car. We regard expenditure above this ceiling as a luxury good, being expenditure above the minimum required to gain access to the use of private transport.

[14] We apply a ceiling to phone purchases, expenditure above the ceiling is considered a luxury good. The reasoning for this is the same as for private vehicles. Expenditure above the ceiling is considered more than the minimum required to gain access to the mobile telecommunications network.

# 3. How significant are infrastructure costs?

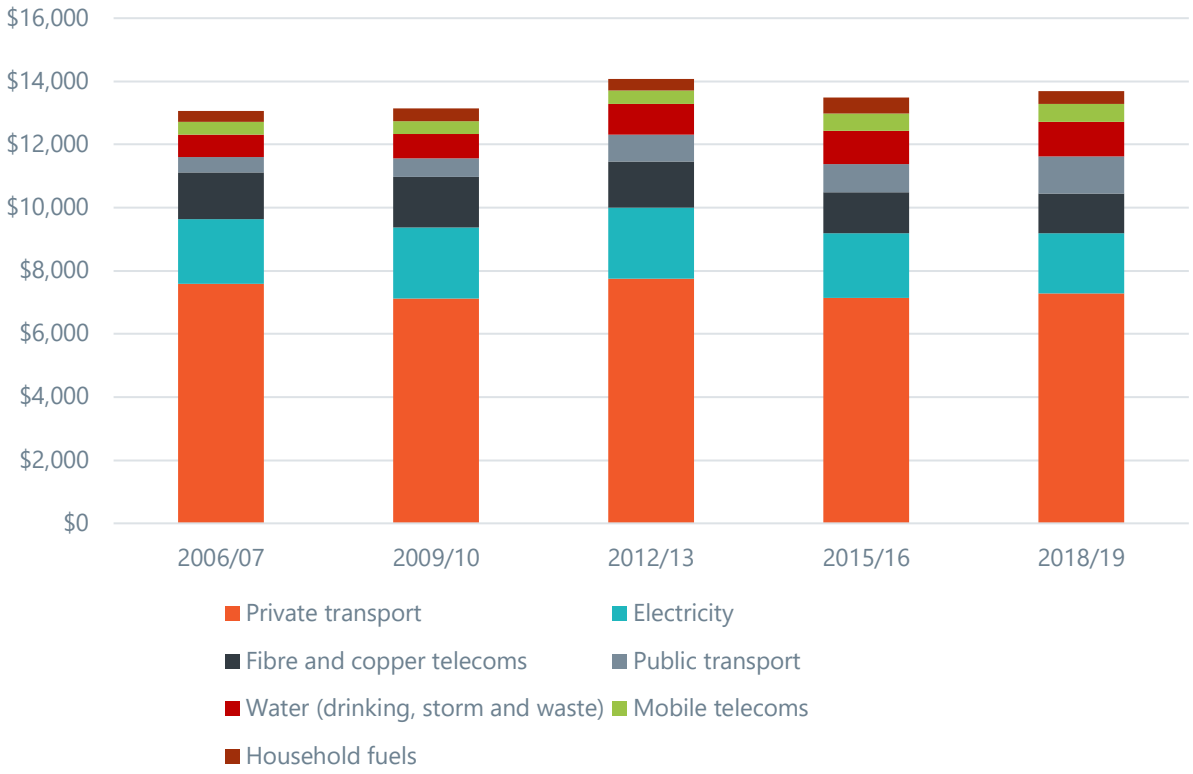
In this section we describe how infrastructure spending has changed over time for the average household in New Zealand, and how much the average household spends on different infrastructure services.

## 3.1. Household infrastructure spending over time

Figure 6 shows how average household infrastructure expenditure has changed over time. Adjusted for inflation, total annual infrastructure spending by the average household rose from $13,100 per year in 2006/07 to $14,100 in 2012/13 and declined to $13,700 in 2018/19.

We observe larger changes in spending on some individual infrastructure services. The largest increase is for public transport spending, which more than doubled from an average of $500 in 2006/07 to $1,160 in 2018/19. This is partly an artefact of how we allocate capital expenditure for long-lived assets.[15] The largest decrease was for fibre and copper telecommunications services, which declined from $1,480 in 2006/07 to $1,260 in 2018/19, a 15% drop.

Figure 6: New Zealand households' average annual infrastructure spending over time (inflation adjusted to 2019 quarter one NZD)

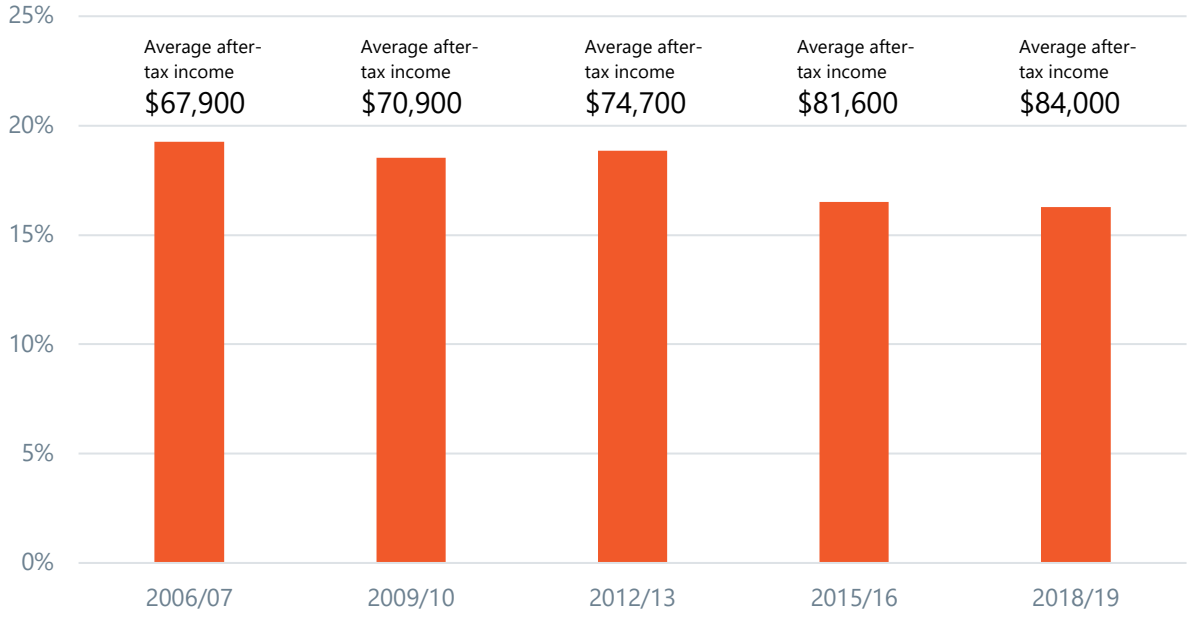



[15] Transport spending allocated to household spending includes a mix of capital expenditure (CAPEX) and operating expenditure (OPEX). We have used the total of CAPEX and OPEX in each year when calculating what households spend on infrastructure services. CAPEX undertaken at a point in time will result in infrastructure that continues to provide services to households over a period of decades and earns revenue from users or beneficiaries over that period. As a result, significant increases in CAPEX may result in a slightly inaccurate view that household spending is rising rapidly over a short period. Overall transport CAPEX has steadily increased over time but doesn't tend to fluctuate up and down between National Land Transport Programme funding. However, individual categories of spending have changed over time, including increased public transport CAPEX for projects like City Rail Link.

Average household infrastructure spending has risen at a slower rate than overall household expenditure and household after-tax income. Between 2006/07 and 2018/19, average inflation-adjusted infrastructure spending rose by 5%, total household expenditure rose by 8%, and average after-tax household income rose by 24%.

As a result, the average household is spending a smaller share of its after-tax income on infrastructure services. Figure 7 shows this trend. In 2006/07, the average household spent 19% of its income on infrastructure services. By 2018/19, this number had dropped to 16%. This decrease is being driven by increases in households' real incomes, rather than reductions in infrastructure spending.

Figure 7: The share of New Zealand households' after-tax income spent on infrastructure services has dropped over time

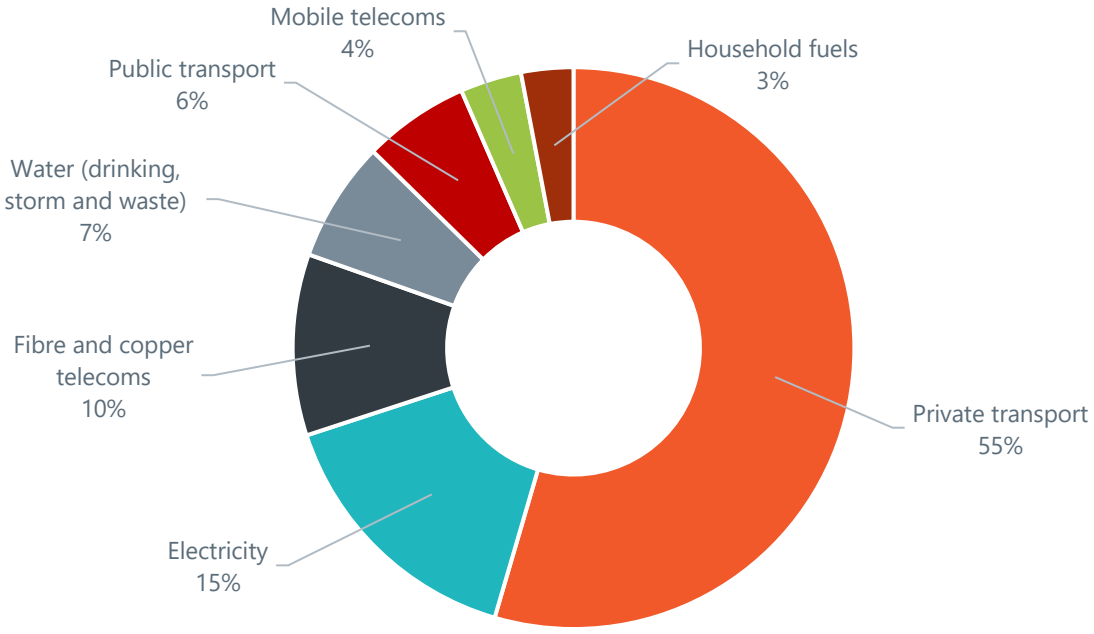



## 3.2. Breakdown of household infrastructure spending

Figure 8 illustrates the composition of the average New Zealand household's infrastructure spending, averaged over all five survey waves.

Private transport services, including the annualised cost of buying and maintaining a 'basic' car, account for the majority (55%) of households' infrastructure spending. This is significantly larger than any of the other categories of spending. Electricity accounts for a further 15% of household infrastructure spending, and fibre and copper telecommunication services account for 10%. The remaining categories – water services, public transport, mobile telecommunications, and household heating fuels – make up the remaining 20% of household infrastructure spending.

Figure 8: Breakdown of New Zealand households' infrastructure spending, averaged over 2006/07 to 2018/19 survey waves



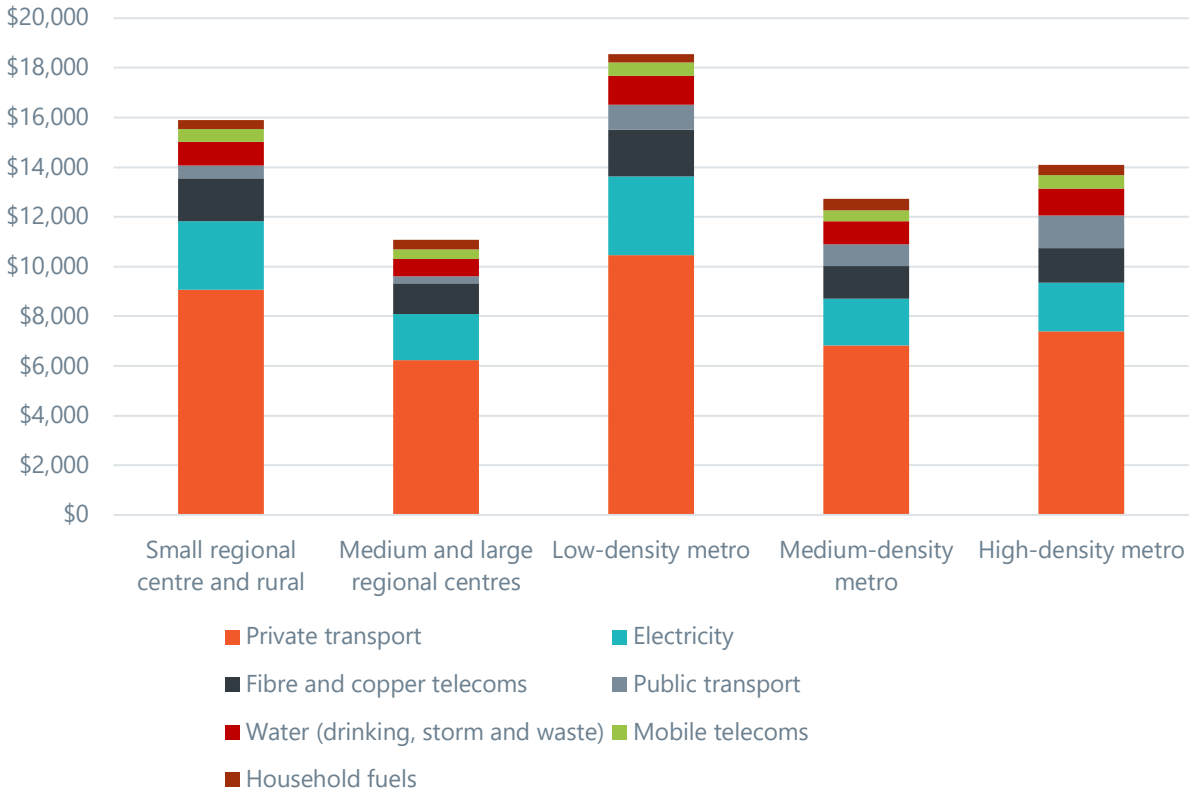
# 4. Do some types of households spend more?

In this section we present data on average household expenditure on infrastructure services for different types of households. Our analysis examines the relationship between infrastructure spending and household location, after-tax household incomes, and household composition. We have not attempted to break down any of the data by household ethnicity or disability status, although we highlight these potential areas for future research.

## 4.1. Spending by household location

Figure 9 shows the average household infrastructure service spending by location. We categorise households according to whether they live in major urban ('metro') areas, medium- to large-sized regional centres, or rural areas and small regional towns. Because most New Zealanders live in metro areas, we break down metro areas into three population density bands.

Figure 9: Average annual household infrastructure spending by location (average 2006/07 to 2018/19; inflation adjusted to 2019 quarter one NZD)




*Metro areas are broken down by statistical area 2 (SA2) population density quintile. Low-density metro are SA2s in quintile one, medium-density metro are SA2s in quintiles two and three, and high-density metro are SA2s in quintiles four and five. Households in the 'small regional centre and rural' category have an average SA2 population density of 394 people per km$^2$, for 'medium and large regional centres' this number is 1,444, for 'low-density metro' 280, for 'medium-density metro' 1,702, and for 'high-density metro' 3,454.*

Average household infrastructure spending is highest in small regional centre and rural areas and in low-density metro areas, and lowest in medium and large regional centres and medium-density metro areas.

There are also some significant differences in the composition of spending. For instance, compared to medium density metro households, small regional centre and rural households spend 34% more on private transport, 48% more on electricity, 32% more on fibre and copper telecommunications, 5% more on water (drinking, storm, and waste), and 12% more on mobile telecommunications. Slightly offsetting this, they spend 43% less on public transport and 19% less on heating fuels.

These differences are likely to be partly explained by differences in access to infrastructure services. For instance, households in rural areas and small regional centres are unlikely to have access to public transport, and hence spend less on public transport but potentially also more on private transport. Similarly, rural households are unlikely to have access to reticulated gas (a heating fuel).

Figure 10 shows that households in small regional centres and rural areas spend the largest portion of their after-tax income on infrastructure services, at 20%, while households in metropolitan areas spend the lowest proportion, at 16%, 17%, and 17% for low-, medium-, and high-density metro areas respectively. Households in medium and large regional centres spend an average of 18% of their after-tax income on infrastructure services.

Because households in small regional centres and rural areas have a similar average income to households in medium and high-density metro areas, the higher infrastructure expenditure share in rural areas appears to be due to higher per-household spending. This could be driven by either higher prices for infrastructure services (for example, higher petrol prices or electricity lines charges) or higher consumption (for example, longer driving distances or greater electricity consumption).

Figure 10: Share of households' after-tax income spent on infrastructure services by location (average 2006/07 to 2018/19)


These locational differences in spending are present in the regression results reported in Appendix C as well. Compared to rural households, medium- and high-density metro households are estimated to spend between $400 and $700 less on private transport, between $100 and $350 less on electricity, and between $20 and $150 less on other household heating fuels. Slightly offsetting this, they spend between $100 and $200 more on public transport and between $50 and $100 more on reticulated household gas.

Low density urban households are estimated to have similar spending to rural households in many ways, despite having much higher average incomes. There are differences between the two groups, namely low-density urban households are estimated to spend $210 more on public transport per year, $160

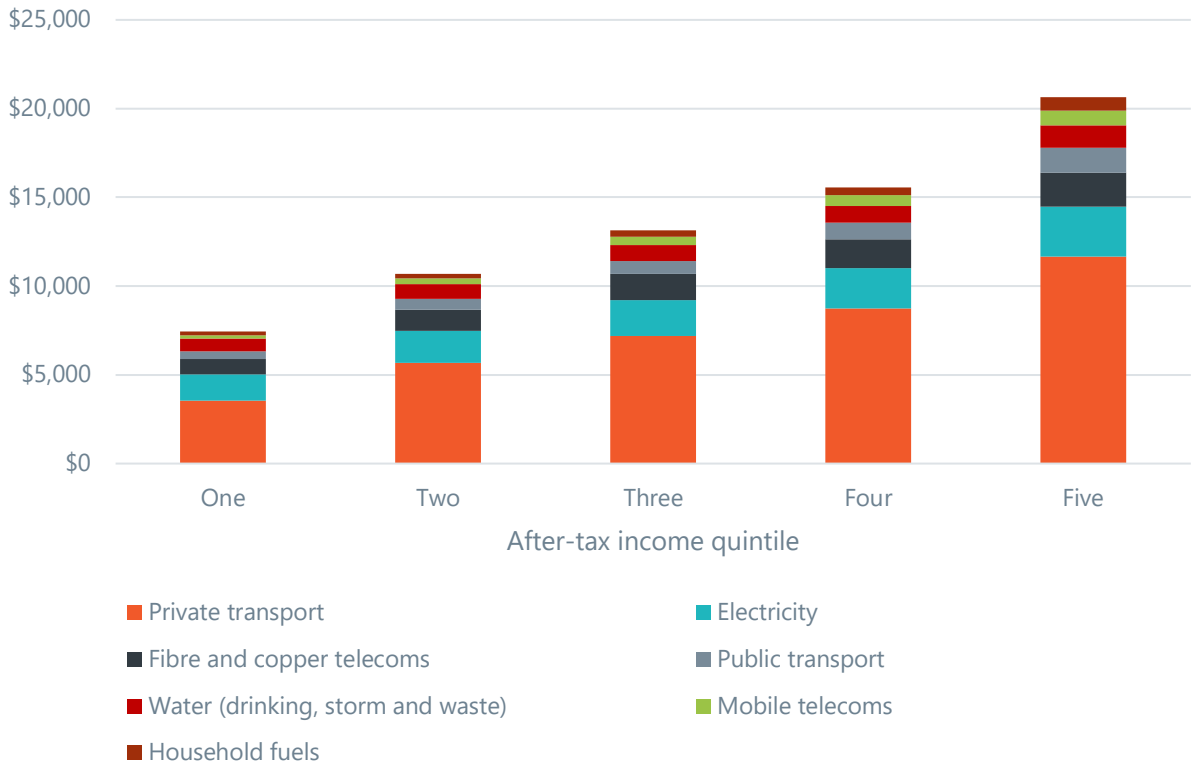
more on electricity, and $80 less on other household fuels. This would suggest these households are living close to urban areas as they are able to use public transport, but still sufficiently far away that they don't have access to the reticulated gas network. They therefore must rely on electricity for their energy needs.

## 4.2. Spending by household income quintile

Figure 11 shows average household infrastructure spending for households with different income levels. We categorise households into five bands (quintiles) based on their after-tax household income.[16]

We find that households with higher incomes spend more on infrastructure services. Households in quintile one, that have the lowest incomes, spent an average of $7,460 per year on infrastructure services over the sample period, while households in quintile five spent an average of $20,640 per year.

Figure 11: Average annual household infrastructure spending by after-tax income quintile (average 2006/07 to 2018/19; inflation adjusted to 2019 quarter one NZD)



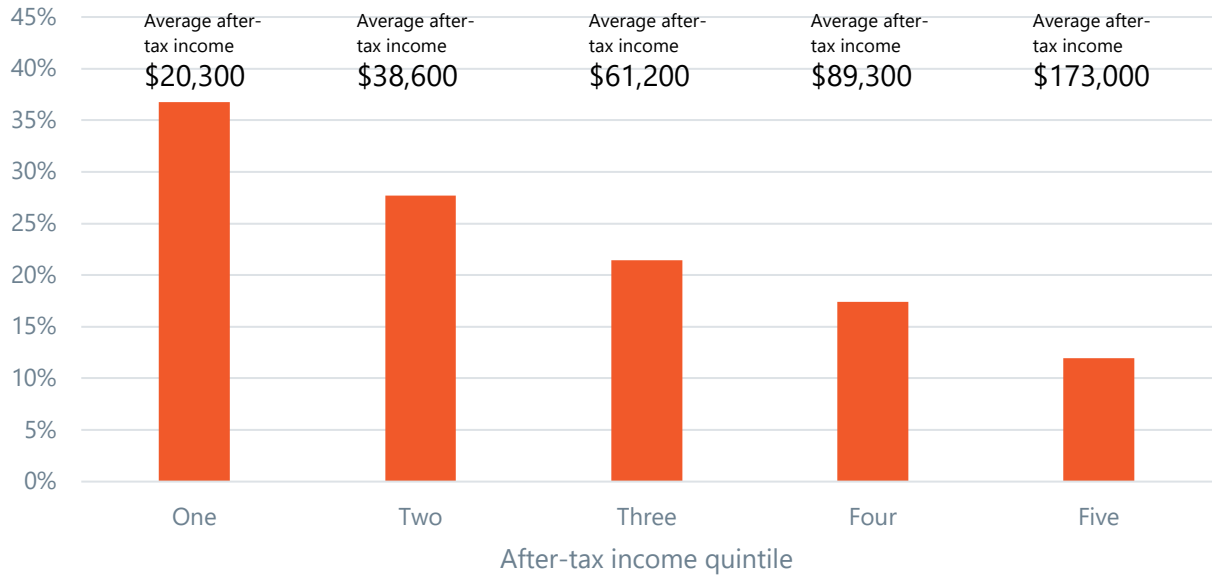

Overall infrastructure spending was 177% higher in quintile five compared with quintile one. Higher-income households spend proportionately more on mobile telecommunications (366% higher), heating fuels (233% higher), and both private and public transport (228% and 210% higher, respectively). While not to the same level, they also spend more on water (drinking, storm, and waste) (77% higher), electricity (90% higher), and fibre and copper telecommunications (125% higher).

Household incomes rise much more rapidly than infrastructure spending. Average after-tax incomes in quintile five are 750% higher than average incomes in quintile one. As a result, the share of household income spent on infrastructure services is much lower in higher income quintiles.

[16] We use un-equivalised household income throughout this report; for a discussion of this choice see Appendix A.

Figure 12 shows that households in quintile one spend an average of around 37% of their after-tax income on infrastructure services, compared with only 12% for households in quintile five. The average share of household income spent on infrastructure services declines with higher household incomes.

Figure 12: Share of households' after-tax income spent on infrastructure services by after-tax income quintile (2006/07 to 2018/19)




## 4.3. Spending by household composition

Figure 13 shows average household infrastructure spending for different types of households. Households are grouped by whether they include a dependent child and whether they have at least one member working. This allows us to understand the impact of work status and children on infrastructure spending.

We find that non-working households tend to spend less than working households, and that households with children spend more than households without children. On average, working households spend roughly $6,200 more than non-working households. Similarly, households with children spend around $2,000 more than households without children. Working households spend almost twice as much as non-working households on private transport.

Additional analysis discussed in Appendix A suggests that non-working households with dependent children are disproportionately likely to report difficulty paying infrastructure bills. A total of 40% of these households reported having difficulty, compared with just 6% of non-working households without children. This compares with 12% of working households with dependent children and 5% of working households with no children.

Figure 14 shows that non-working households spend a larger share of their income on infrastructure services compared to working households. This is due mainly to large differences in income between these groups. Households with children spend a slightly larger share of their after-tax income on infrastructure compared to households without children. As households with children tend to have higher after-tax incomes, this indicates that children substantially add to a household's infrastructure expenditure.[17]

[17] Higher incomes for households with children could be partly explained by the Working for Families Tax Credits. These are payments for families with dependent children and may partially offset the increased infrastructure costs for these households.

Figure 13: Average annual household infrastructure spending by household composition (annual, 2006/07 to 2018/19; inflation adjusted to 2019 quarter one NZD)

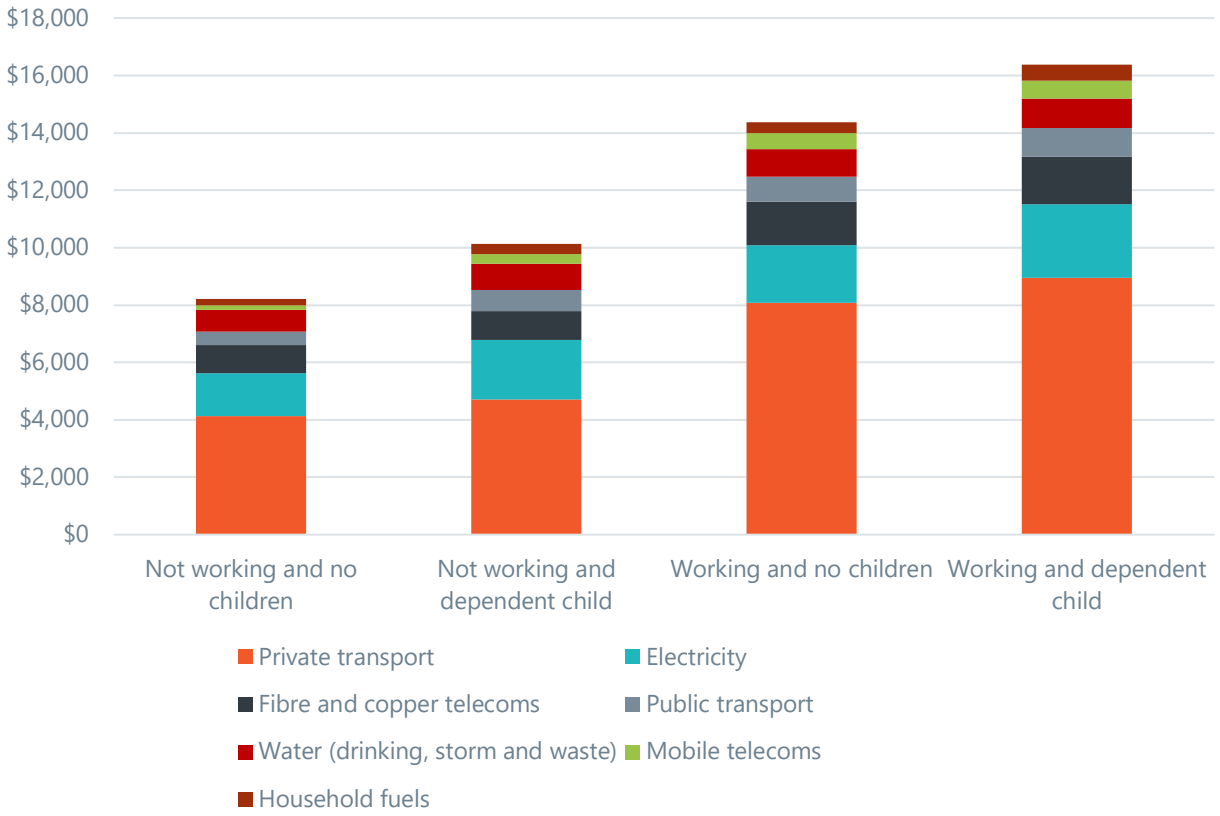



Figure 14: Share of households' after-tax income spent on infrastructure services by household composition (2006/07 to 2018/19)

# 5. Comparisons to international research

In this section we compare our estimates of household infrastructure spending with international data on household expenditure. To facilitate comparison, we look at figures in terms of share of after-tax income or share of total household expenditure. However, we note that these comparisons may be affected by methodological differences between the datasets.

We compare our results with previous Australian research on overall household infrastructure spending and with United Kingdom and United States data on spending on transport services. We also compare our estimates of household electricity spending with other New Zealand data.

## 5.1. Australian comparison

The Australian Household Expenditure Survey, conducted every six years, is the Australian counterpart to Stats New Zealand's Household Economic Survey.[18] A 2019 report uses this data to examine Australia's household infrastructure spending. The report found that the average Australian household's annual infrastructure bill was $16,400 in 2015/16 (June 2016 AUD), up 13% in real terms from 2003/04.

Table 4 shows that New Zealand households spent a larger share of their after-tax income on infrastructure services in 2009/10, but that this difference had closed to within one percentage point by 2015/16. In 2015/16, New Zealand households spent a larger share of their income on electricity, a slightly lower share on transport, and roughly the same share on water and telecommunication services. Notably, Australian households' spending on telecommunication services increased, as a share of income, over this time, while New Zealand households' spending fell.

Table 4: Share of household after-tax income spent on different infrastructure services in Australia and New Zealand

| Infrastructure component | Australian 2009/10 | New Zealand 2009/10 | Australian 2015/16 | New Zealand 2015/16 |
|---|---|---|---|---|
| **Water** | 1.0% | 1.1% | 1.2% | 1.3% |
| **Energy** | 1.9% | 3.7% | 2.0% | 3.1% |
| **Transport** | 11.4% | 10.9% | 10.2% | 9.9% |
| **Telecommunications** | 2.0% | 2.9% | 2.2% | 2.3% |
| **Total** | 16.4% | 18.5% | 15.6% | 16.5% |

*Australian data: University of NSW City Futures Research Centre and Astrolabe Group, 2019. New Zealand data: Energy = electricity + heating fuels, transport = private transport + public transport, and telecommunications = mobile telecoms + fibre and copper telecommunications.*

Table 5 shows that New Zealand and Australian households have similar expenditure patterns when households are grouped by income quintile.

New Zealand households in the lowest two quintiles appear to spend a slightly larger portion of their income on infrastructure services relative to their Australian counterparts and the highest two quintiles appear to spend a slightly smaller share. New Zealand households in the middle third quintile are then

[18] See https://www.abs.gov.au/methodologies/household-expenditure-survey-australia-summary-results-methodology/2015-16 for more details.

largely aligned with the Australian third quintile households. For every income quintile in both countries, the percentage of income spent on infrastructure services declined between 2009/10 and 2015/16.

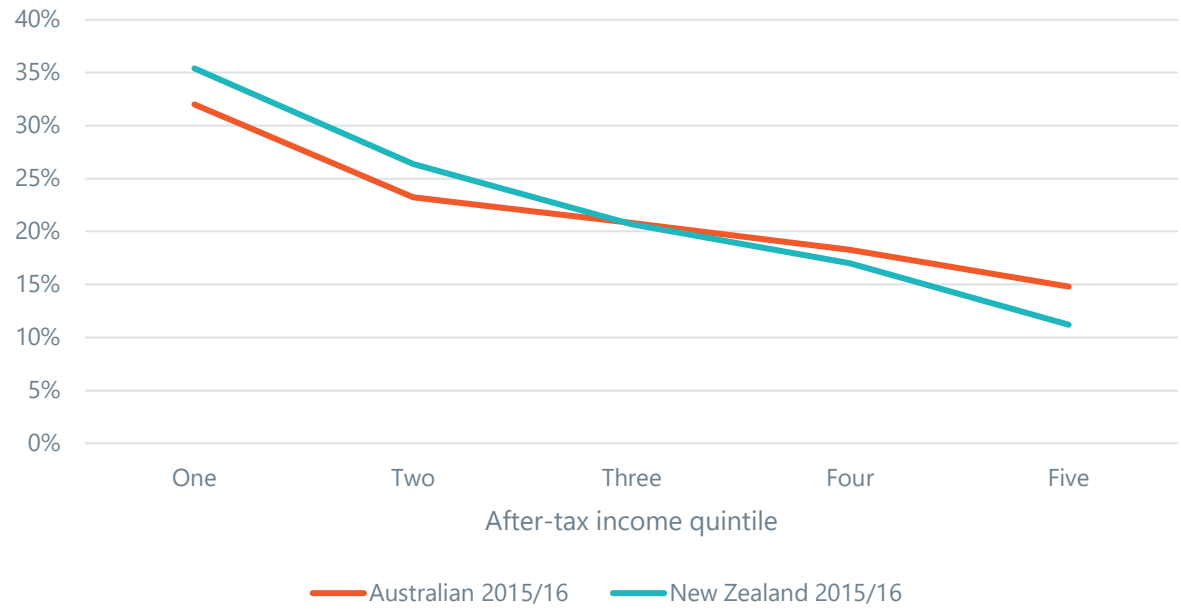
Table 5: Share of household after-tax income spent on infrastructure services by income quintile in Australia and New Zealand

| Income quintile | Australian 2009/10 | New Zealand 2009/10 | Australian 2015/16 | New Zealand 2015/16 |
|---|---|---|---|---|
| **One** | 34.4% | 36.5% | 32.0% | 35.4% |
| **Two** | 24.3% | 28.4% | 23.2% | 26.4% |
| **Three** | 21.3% | 21.7% | 20.8% | 20.7% |
| **Four** | 18.6% | 18.2% | 18.3% | 17.0% |
| **Five** | 15.7% | 12.3% | 14.8% | 11.2% |

*Australian data: University of NSW City Futures Research Centre and Astrolabe Group, 2019*

Figure 15 graphs the share of income spent on infrastructure services by after-tax income quintile for Australia and New Zealand for the survey year 2015/16. The share of income spent on infrastructure services declines with increasing incomes in both countries, but low-income households spend a bit less and high-income households spend a bit more in Australia.

Figure 15: Share of household after-tax income spent on infrastructure services by income quintile in Australia and New Zealand, 2015/16




Different household expenditure patterns can likely be explained by methodological differences. The Australian report includes actual vehicle purchase costs whereas we have used an annualised capital maintenance cost of $1,500 per annum per car, based on the cost to own a 'basic' car. However, it is possible that low-income households spend less than $1,500 per car per year and that higher income households spend more. Because transport accounts for most of household spending on infrastructure services, this difference may affect the shape of the relationship shown in Table 5 and the curves in Figure 15.

Ultimately, what stands out from Table 4 and Table 5 is that Australian and New Zealand households have similar infrastructure spending profiles, regardless of time or income quintile.

## 5.2. United Kingdom comparison

The United Kingdom's Office for National Statistics collects the Living Costs and Food (LCF) survey, which is similar to Australian and New Zealand household expenditure surveys (Office for National Statistics (ONS), 2022). The LCF is a voluntary sample of private households who complete a household interview and an expenditure diary for two weeks.

Table 6 shows the share of total household expenditure spent on private transport and on public transport by household income quintile in New Zealand and the UK. We find opposite patterns. In the UK, higher income households spend a greater share of their total expenditure on both private and public transport, whereas higher income New Zealand households spend a smaller share on transport.

Table 6: Share of total household expenditure spent on private and public transport, by income quintile, in the UK and New Zealand, 2018/19

| UK gross income quintile | One | Two | Three | Four | Five | Overall |
|---|---|---|---|---|---|---|
| % expenditure on private transport | 6.1% | 9.5% | 10.4% | 11.6% | 11.5% | 10.6% |
| % expenditure on public transport | 2.8% | 2.6% | 2.8% | 3.2% | 4.2% | 3.4% |
| **NZ after-tax income quintile** | **One** | **Two** | **Three** | **Four** | **Five** | **Overall** |
| % expenditure on private transport | 13.0% | 12.6% | 12.3% | 11.4% | 10.0% | 11.9% |
| % expenditure on public transport | 2.3% | 1.9% | 1.8% | 1.7% | 1.7% | 1.9% |

*Office for National Statistics (ONS), 2022*

The pattern and shares for each quintile have been fairly consistent between 2006 and 2018 in the UK data. Across all UK households, transport spending has fluctuated between a low of 13% of total household expenditure and a high of 14%.

Once again, methodological differences may affect these comparisons. The United Kingdom data includes vehicle purchases, whereas we opt to use an annualised cost of ownership per car. Including actual vehicle costs is likely to raise the share of expenditure on private transport for high-income New Zealand households and lower it for low-income New Zealand households. Similarly, differences in public transport spending profiles are likely to be partly explained by methodological differences. The United Kingdom data includes air, taxi, minicab, and ferry fares in public transport, whereas we do not include expenditure on these items. Including these would likely increase higher income households' public transport expenditure much more than it would increase lower income households' expenditure,

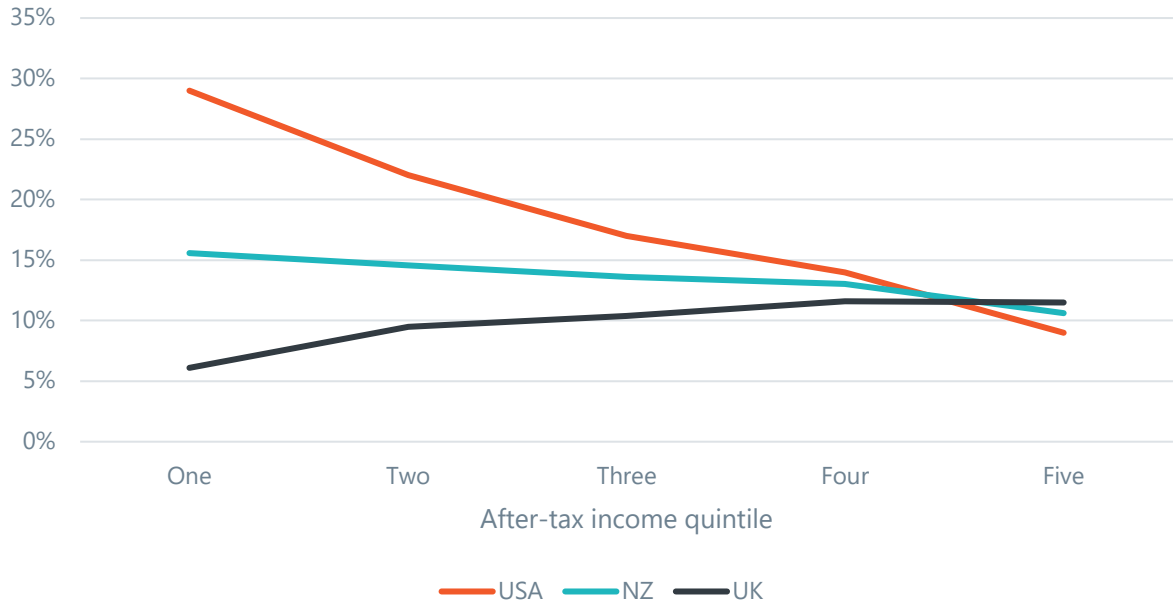
## 5.3. United States comparison

Previous analyses of household expenditure data suggest that the correlation between household incomes and transport's share of household expenditure is different in the United States than it is in the

United Kingdom and other European countries (Institute for Transportation and Development Policy, 2019).

Figure 16 shows how households' transport spending, as a share of overall expenditure, varies across income quintiles in New Zealand, the United Kingdom, and the United States. Low-income households in the United States spend 29% of their total expenditure on transport, compared with 16% for low-income New Zealand households and 6% for low-income United Kingdom households. American transport expenditures are higher, as a share of household budgets, for the bottom four quintiles of household income. However, high-income United States households spend only 9% of their budgets on transport, compared with 11% for high-income New Zealand households and 12% for high-income United Kingdom households.

Figure 16: Transport share of total household expenditure by after-tax income quintile in New Zealand, the United Kingdom, and the United States




*United Kingdom data: Office for National Statistics (ONS), 2022; US data: Institute for Transportation and Development Policy, 2019. Note: United States data and United Kingdom data includes actual vehicle purchase costs, while New Zealand data includes annualised capital maintenance charge of $1,500 per year per car which likely flattens the curve.*

## 5.4. Comparison with previous New Zealand analysis

Stats New Zealand's Household Expenditure Survey is widely used for analysis of household income, wealth, and spending. The Ministry of Social Development's *Household Income in New Zealand* report is a key example.[19] It provides information on the material wellbeing of New Zealanders, including analysis of trends and patterns in household incomes and, in years where households are asked to fill out the expenditure module of the HES, analysis of household spending on housing services. However, it does not specifically focus on household infrastructure spending.

To the best of our knowledge, the only existing comparable reports in the New Zealand context have analysed household expenditure on energy and attempting to define household energy hardship. A 2022 Ministry of Business, Innovation and Employment (MBIE) report used electricity retail market data to quantify average annual household expenditure and electricity consumption.

[19] See https://www.msd.govt.nz/about-msd-and-our-work/publications-resources/monitoring/household-incomes/ for the full report.

Table 7 and Figure 17 show that while the HES and MBIE estimates are similar, the HES data appear to be slightly 'ahead' of the MBIE data, peaking and declining slightly earlier. This is likely due to methodological differences. The MBIE data are sales-based, derived mainly from information from electricity retailers, whereas the HES data are derived from household expenditure diaries, which may suffer from reporting errors.

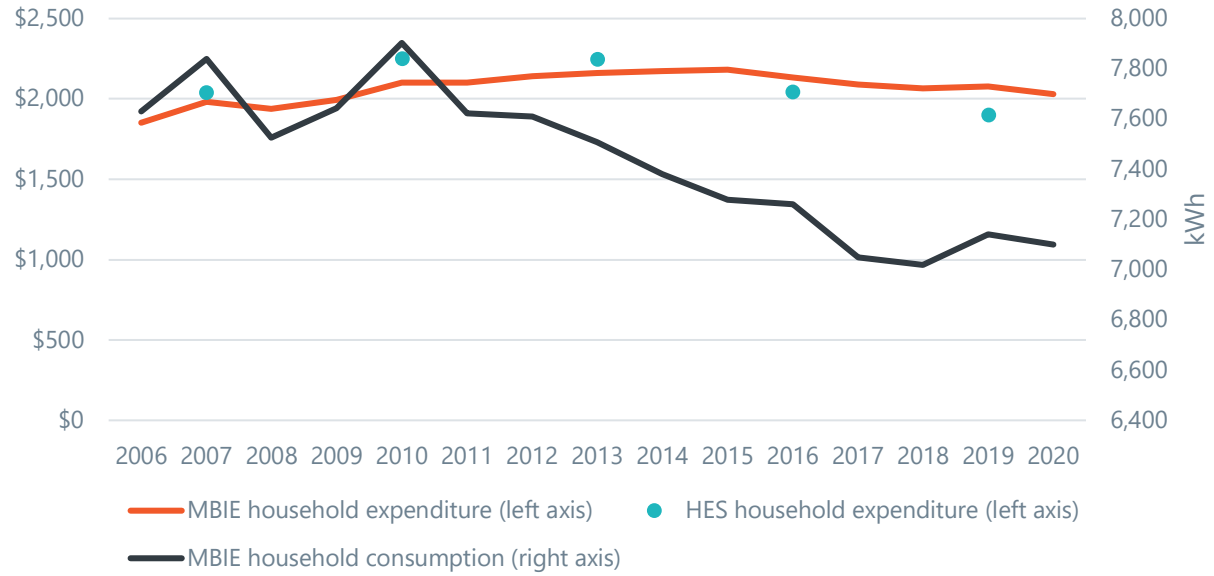
Over the full 2006 to 2020 period, electricity spending rose until 2015 before steadily declining through to 2020. Annual electricity consumption varied significantly between 2006 to 2011 but declined from 2012 to 2020. This implies that residential electricity prices increased between 2012 and 2020, as consumption fell faster than expenditure. Because the MBIE data are only available in terms of annual averages for all households, it does not allow us to compare spending by household income quintiles.

Table 7: Comparison of HES estimates of electricity spending with MBIE data (annual, inflation adjusted to 2019 quarter one NZD)

| Year | 2006/07 | 2009/10 | 2012/13 | 2015/16 | 2018/19 |
|---|---|---|---|---|---|
| **HES data** | 2,038 | 2,251 | 2,246 | 2,044 | 1,901 |
| **MBIE data** | 1,918 | 2,049 | 2,152 | 2,157 | 2,072 |

*(MBIE, 2022). MBIE data are based on calendar year, therefore, to align with the HES survey years the simple average of the two relevant years is taken.*

Figure 17: Average annual expenditure on and consumption of electricity by New Zealand households (annual; inflation adjusted to 2019 quarter one NZD)




*MBIE, 2022*

# 6. Do some individual households spend more?

The previous sections provide data on average infrastructure spending, either for all New Zealand households or for groups of similar households. However, averages can conceal significant variation between individual households. For instance, two neighbouring households with similar incomes may nonetheless spend very different amounts on transport, depending upon where they work and how far they need to commute.

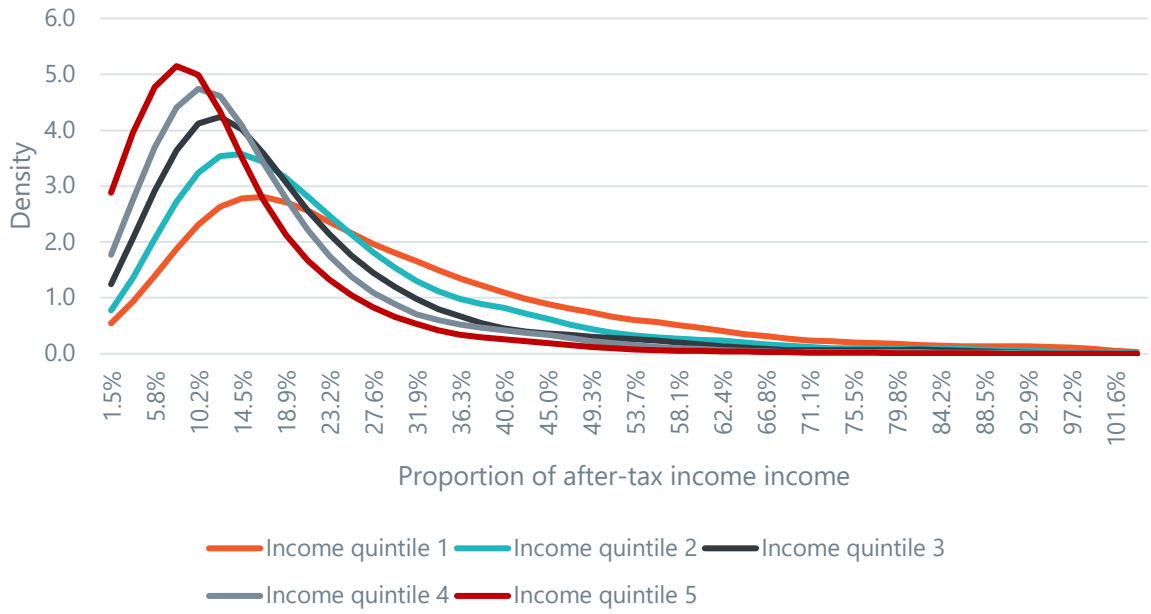
In this section, we therefore look at how household spending on infrastructure varies *within* groups of similar households.

To do so, we use Household Economic Survey microdata to measure and plot variation in household spending within categories of households. The charts in this section show the smoothed distribution of household infrastructure spending.[20]

## 6.1. Variation in spending within income quintiles

Figure 18 shows the distribution of infrastructure spending as a share of after-tax income within each income quintile. As previously discussed, low-income households spend a larger share of their income on infrastructure services, on average.

Figure 18: Distribution of infrastructure spending as a share of after-tax income, within after-tax income quintiles (2006/07 to 2018/19)




However, there is more variation in infrastructure spending *within* each income group than there is *between* them. This suggests that while income is an important factor in explaining household spending

[20] The technical name for such a graph is a kernel density plot. Appendix B describes how we calculated these graphs.

on infrastructure services, many other factors, such as location and household composition, also influence infrastructure spending.[21]

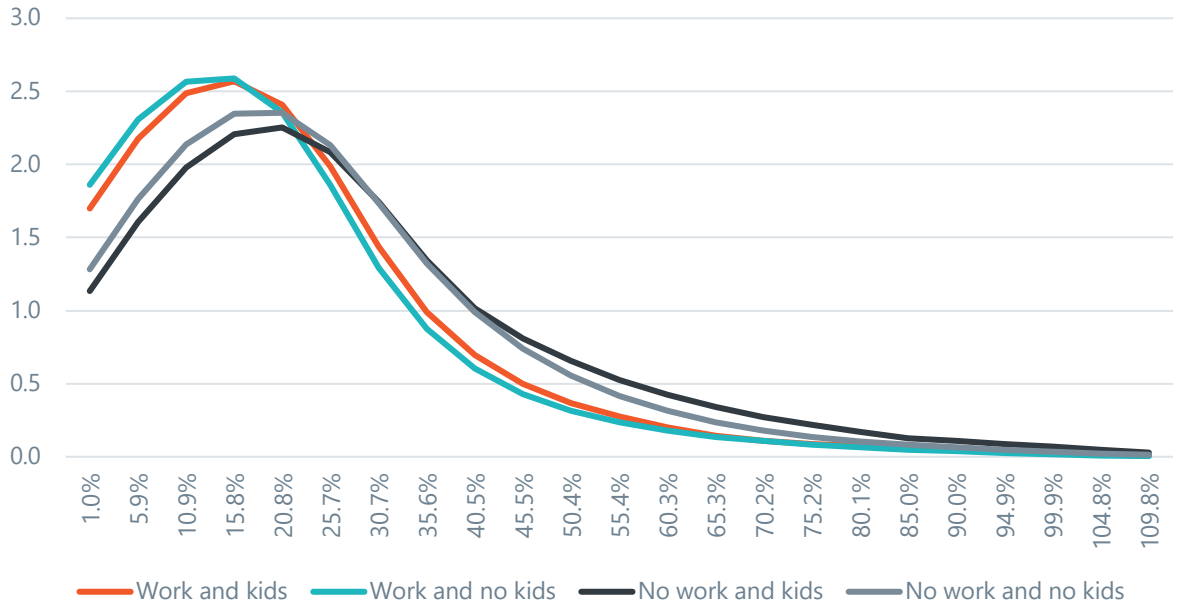
The distribution of spending overlaps significantly between income quintiles. For instance, the average household in the lowest-income quintile spends around 37% of their income on infrastructure services. However, kernel density estimates suggest that one in six households in this group spend less than 10% of their income on infrastructure services – less than the average household in the highest-income quintile. Large variation in infrastructure spending, as a share of income, in low-income categories is partly since these categories include a mix of retirees, students, low-paid workers, and unemployed workers, who are likely to have different needs for infrastructure.

## 6.2. Variation in spending within household types

There are smaller differences in the distribution of spending between households with and without children. Households with children tend to spend a slightly larger share of their income on infrastructure services, although distributions of spending are very similar. As previously shown, households with children earn slightly higher after-tax income than households without children, but this is more than offset by higher infrastructure spending. This suggests that children increase households' infrastructure needs.

Figure 19 shows the distribution of infrastructure spending as a share of after-tax income within different types of households. Here we find fewer differences between distributions. The most obvious difference is between households with at least one (paid) worker and households with no workers. Working households spend a smaller portion of their incomes on infrastructure services than non-working households. As previously shown, working households have higher total spending on infrastructure services but this is more than offset by their higher incomes.

Figure 19: Distribution of infrastructure spending as a share of after-tax income, within household types (2006/07 to 2018/19)




[21] Appendix C presents some econometric analysis that explores the influence of all these factors. A notable finding from this analysis is that observable factors, such as income, location, and household composition, only explain a bit less than half of observed variation in infrastructure service expenditure. This suggests that there is a large role for other factors, like household preferences.

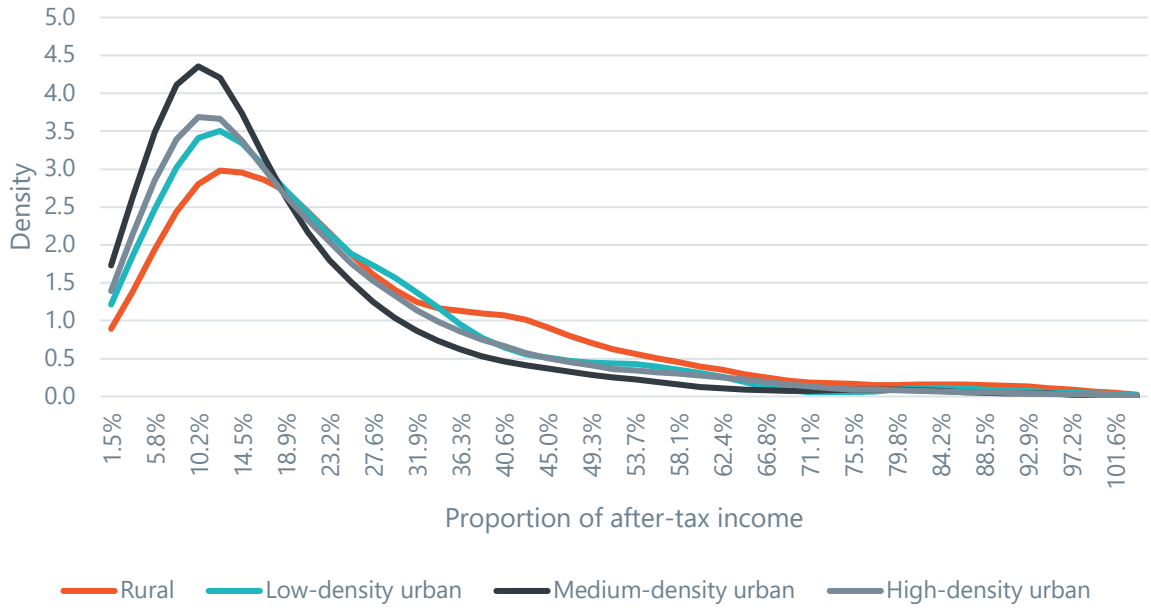
## 6.3. Variation in spending within locations

Figure 20 shows the distribution of infrastructure spending as a share of after-tax income within different locations. Only the distributions for rural households and for metro households with SA2 population densities in the first, third, and five quintiles are shown to avoid cluttering the chart.

Distributions of spending are reasonably similar for all four groups. The distribution for medium-density urban households has the tightest spread, suggesting that this is the most homogenous group of households.

The distribution of spending for rural households is more spread out than distributions for other locations. While the average rural household spends around 20% of its income on infrastructure services, one in four rural households appear to spend more than 35% of their income on infrastructure services. This may suggest that there is a subgroup of rural households that are more likely to face difficulty affording infrastructure services.

Figure 20: Distribution of infrastructure spending as a share of after-tax income, within locations (2006/07 to 2018/19)



# 7. How does infrastructure spending change when incomes rise?

In this section, we examine how household infrastructure spending changes in response to household income. We use household microdata to estimate cross-sectional income elasticities for infrastructure spending, controlling for other observable factors that might also affect infrastructure spending. Appendix C provides further details on our econometric analysis.

## 7.1. Interpreting and using income elasticities

These income elasticities measure how sensitive infrastructure spending is to income. An elasticity of 1 indicates that a 1% increase in income is associated with a 1% increase in infrastructure spending. Smaller elasticities suggest that infrastructure spending increases more slowly than income – for instance, an elasticity of 0.2 indicates that a 1% increase in income is associated with only a 0.2% increase in spending.

Income elasticities can help us understand current and future demand for infrastructure. If infrastructure spending (and use) is highly responsive to incomes, we might expect infrastructure use to be higher in places with higher-income residents, relative to places with lower-income residents. This might affect the amount of infrastructure that might be needed in different places.

Similarly, if infrastructure spending (and use) tends to rise as incomes increase, then future increases in per-capita incomes will result in increased demand for infrastructure even if the population is not growing.

Past research shows that income elasticities of infrastructure demand tend to be less than 1 (National Infrastructure Commission, 2018). That means that infrastructure spending and use will tend to rise more slowly than incomes. As a result, we would expect higher-income households to spend a smaller share of their incomes on infrastructure services than lower-income households (as we see in the New Zealand data). We would also expect higher-income countries to invest a smaller share of their national income in infrastructure than lower-income countries (Cubas, 2020).

## 7.2. Income elasticities for infrastructure spending in New Zealand

Table 8 shows estimated income elasticities for infrastructure spending for New Zealand households from a series of ordinary least squares (OLS) regressions using household-level data. These are cross-sectional regressions, meaning that we analyse variations between different households at a point in time, rather than looking at how income and spending changes over time within households. They control for other observable factors that might affect infrastructure spending, like household size and location.

For all infrastructure spending, and for spending on each category of infrastructure service, we report two types of estimates:

- Income elasticities for total expenditure – these estimates include spending on access charges or fixed charges as well as spending on variable charges that scale with infrastructure use.
- Income elasticities for variable expenditure – these estimates only include spending on variable charges, which provide a reasonable proxy for level of infrastructure use.

Our key finding is that cross-sectional income elasticities are positive but well below 1 for all types of infrastructure services. Income elasticities range from around 0.1 to 0.3, indicating that a 1% increase in incomes is associated with only a 0.1% to 0.3% increase in infrastructure spending and use.

These estimates are towards the lower end of international estimates of income elasticities of demand for infrastructure. The UK National Infrastructure Commission (2018) finds income elasticity estimates tend to range between 0.2 and 1.1, depending upon network and location. Our lower estimates are likely to reflect our use of cross-sectional household data. Meta-analyses of income elasticities of demand for infrastructure services consistently find that cross-sectional methods, which compare different households or individuals at a point in time, result in lower estimates than methods that look at how household or individual demand changes over time (Binsuwadan et al., 2023; Gallet and Doucouliagos, 2014; Sebri, 2014).

Table 8: Estimated income elasticities of infrastructure spending in New Zealand

| Infrastructure service | Total expenditure | Variable expenditure |
|---|---|---|
| **All infrastructure services** | 0.242 | 0.306 |
| | (100% of households) | (99%) |
| **Private transport** | 0.294 | 0.289 |
| | (100%) | (83%) |
| **Public transport** | 0.371 | 0.182 |
| | (99%) | (12%) |
| **Electricity** | 0.110 | 0.113 |
| | (92%) | (91%) |
| **Fibre and copper telecommunications** | 0.143 | 0.250 |
| | (88%) | (56%) |
| **Mobile telecoms** | 0.225 | 0.210 |
| | (39%) | (38%) |

*In parentheses is the percent of households in the sample that had spending above zero. Households with zero spending are dropped from the sample when taking the natural logarithm, potentially leading to a selection issue. All coefficients are statistically significant at the 1% level.*

## 7.3. Factors that influence households' decisions to use infrastructure services

A challenge for estimating income elasticities is that some households may not have access to some infrastructure services or may choose not to use those services. Table 8 shows the percentage of households with non-zero expenditure on each type of infrastructure service. Some models only include a share of the approximately 16,000 households for which we have data, indicating that some households do not use these services.

This is most apparent for public transport, where only 12% of households reported non-zero variable expenditure on public transport fares, and for mobile telecommunications, where only 38% of households reported non-zero variable expenditure. The low share of households reporting mobile telecommunication spending is likely to be due to the fact that mobile phone market share was lower in earlier survey waves.

To address this issue, we estimate supplemental regressions that model household infrastructure spending in two steps. The first step is to model the 'participation' decision, where the household decides whether it wants to consume any of the good or service. The second step is to model the

'amount' decision, where the household decides how much of the good or service it wants to consume. We implement this using Cragg's truncated normal hurdle model, which is explained further in Appendix C.

Table 9 shows the estimated marginal effect of increasing annual household after-tax income by $1,000 on variable infrastructure spending decisions. The middle column shows the marginal effect on the probability of the household consuming the service and the third column shows the marginal effect on the amount of the service consumed. These estimates also control for other observable factors that might affect infrastructure spending, like household size and location.

While these results cannot be directly compared with the above income elasticity estimates, they suggest that:

- Higher incomes are associated with small but statistically significant increases in the probability of using private transport, public transport, and mobile telecommunications, but a small decrease in the probability of using networked electricity.
- For households that choose to use infrastructure services, higher incomes are associated with small but statistically significant increases in use of private transport, public transport, electricity, fibre and copper telecommunication services, and mobile telecommunications.

This reinforces our conclusion that cross-sectional income elasticities of infrastructure spending are positive but less than 1.

Table 9: Estimated impacts of increased household income on annual variable infrastructure spending

| Infrastructure service | Marginal effect of an additional $1000 annual income on probability of consuming the service | Marginal effect of an additional $1000 annual income on the amount of the service purchased annually |
|---|---|---|
| **Variable private transport** | 0.0002*** | 8.64*** |
| | (0.0001) | (0.69) |
| **Variable public transport** | 0.0001*** | 0.25** |
| | (0.0000) | (0.11) |
| **Variable electricity** | -0.0002*** | 1.49*** |
| | (0.0000) | (0.20) |
| **Variable fibre and copper telecommunications** | 0.0000 | 1.04*** |
| | (0.0001) | (0.16) |
| **Variable mobile telecommunications** | 0.0005*** | 1.16*** |
| | (0.0001) | (0.11) |

*Standard errors in parentheses, *** = p<0.01, ** = p<0.05, * = p<0.1. Note: these coefficients are in levels.*

We report full regression results in Appendix C. An important finding from this analysis is that factors other than income have a stronger impact on households' probability of using infrastructure services and their amount of usage.

For instance, we find that increasing household income by $1,000 is associated with a 0.02 percentage point increase in the probability of using private transport and a $9 increase in variable spending on private transport. In comparison, an additional adult member of the household is associated with a 6.5 percentage point increase in the probability of using private transport and an $1,080 increase in variable spending, and an additional child is associated with a 2.5 percentage point increase in the probability of using private transport and an $320 increase in variable spending. Work status of household members and whether the household lives in rental housing also have strong effects on spending patterns.

# 8. Conclusion

This paper aims to improve our understanding of household spending on infrastructure services. It covers land transport (roading and public transport), energy (electricity, gas, and heating fuels), water (drinking, storm, and waste), and telecommunications (mobile and fixed-line).

It uses data on household expenditure and incomes from five waves of Statistics NZ's Household Economic Survey (HES), between 2006/07 and 2018/19. We use this data to estimate individual households' spending on infrastructure services, accounting for different funding mechanisms for different types of infrastructure and accounting for 'access costs' to use infrastructure networks.

## How much do households spend on infrastructure services?

The average New Zealand household spent around 16% of its after-tax income on infrastructure services in 2018/19, which is the most recent year for which data is available. That is slightly over $13,500 per year, or around $260 per week. Households' infrastructure spending has risen over time, but incomes have risen more rapidly. As a result the share of after-tax income spent to infrastructure services has declined over time – it was over 19% in 2006/07.

Private transport is by far the largest component of household infrastructure spending, at 55% of total infrastructure spending. That is followed by electricity (15%), telecommunications (14%), water (drinking, storm, and waste) (7%), and public transport (3%).

## Higher-income households spend more on infrastructure, in total…

We divided the households in our study into five quintiles based on their after-tax household income. The average household in the highest income quintile spent around $20,600 per year on infrastructure services, while the average household in the lowest income quintile spent around $7,400 per year.

## … but they tend to spend a smaller share of their income

While households spend more on infrastructure services as their income increases, their spending does not rise as quickly as does their income. On average, a 1% increase in household income is associated with a 0.24% increase in overall infrastructure spending.

Lower-income households therefore tend to spend a larger share of their after-tax income on infrastructure services. Households in the lowest income quintile spend 37% of their after-tax income on infrastructure, while households in the highest income quintile spend 12%.

## Infrastructure tends to be more affordable in cities

Household infrastructure spending varies considerably between different types of locations.

We categorise households into five groups: rural areas and small regional centres, medium to large regional centres, and low-density, medium density, and high-density areas of large cities.

Both household incomes and infrastructure spending vary between these categories. Households living in large cities spend the smallest share of their after-tax incomes on infrastructure services (16-17%, depending upon density of the area where people live). Households living in medium and large regional centres spend slightly over 18% of after-tax income. Households living in rural areas small regional centres or rural areas spend the most, at slightly over 20% of after-tax income.

## Infrastructure tends to be more affordable for working households

Working households tend to spend a smaller share of their after-tax income on infrastructure services than non-working households. For instance, working households with children spend around 17% of their income on infrastructure services, compared with 27% for non-working households with children. On average, having children results in a 1 percentage point increase in the share of household income spent on infrastructure services.

## There is more variation within groups than between groups

We find that variation within groups of similar households is larger than variation between groups. Households that are fairly similar – in terms of income, location, and household composition – often spend very different amounts on infrastructure.

For example, the average household in the lowest income quintile spends around 37% of its income on infrastructure services, which might indicate challenges with the affordability of infrastructure services. However, many low-income households appear to face smaller affordability challenges. We estimate that one in six low-income households spend less than 10% of their income on infrastructure services – a lower ratio than the average household in the highest income quintile.

Similarly, while the average rural household spends around 20% of its income on infrastructure services, one in four rural households appear to spend more than 35% of their income on infrastructure. This suggests that some, but not all, rural households may face difficulty affording infrastructure services.

This highlights that average infrastructure spending for a group of households is an unreliable indicator of infrastructure services affordability for each individual household within that group.

For instance, slightly more than half of households in the lowest income quintile (52%) were retiree households, and a small minority of these households were comprised of students (4%). These households are different than beneficiary households (23%) and low-income working households (17%). While retirees generally have low incomes, they are more likely than other groups to own their own homes. University students currently have low incomes, but they can expect to earn higher incomes in the future after completing their education. Their ability to afford infrastructure may differ as a result.

Within group differences reflect different decisions about how and when households use different infrastructure services. As a result, assessing the affordability of infrastructure services is more complex and nuanced than simply comparing average spending for households with similar income or demographic characteristics. This diversity of experience also means that it can be challenging to effectively target assistance to those in need.

## Spending patterns vary between countries

We compared our findings on household infrastructure spending with similar analyses of household infrastructure spending in Australia, the United Kingdom, and the United States. These comparisons are challenging due to methodological differences between countries, and as a result we caution against drawing strong conclusions about those differences.

With that important caveat in mind, we find that patterns of household spending on infrastructure are broadly similar in New Zealand and Australia. Average households in both countries spend similar shares of their after-tax incomes on infrastructure services. Spending patterns across income quintiles are also similar.

Patterns of household spending on transport vary significantly between countries, potentially reflecting different approaches to providing and using transport infrastructure. In the United States, low-income households spend a much larger share of their income on transport than high-income households. In the United Kingdom, the opposite pattern holds – high-income households spend a larger share of their income on transport. New Zealand is somewhere between those two countries.

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# Appendix A: Measuring household incomes

## A. 1. Disposable ('after-tax') income

Our primary classification of households for this project is by disposable income quintile. Disposable income is gross recorded income for all household members less income tax paid. We used the disposable income column in the Integrated Data Infrastructure for households surveyed in the 2018/19 Household Economic Survey. For prior survey years, we estimated tax paid by each individual using the income tax tables that applied in the relevant financial year, then subtracted those estimates from gross household income.

## A. 2. What about equivalised household income?

Income equivalisation is an adjustment to incomes, based on three points:

1. household expenditure increases with the number of people in the household – each extra person adds cost
2. children are (on average) less costly than adults
3. it is cheaper for two or more people to live together at a given standard of living, than for those people to live separately.

The various income equivalisation methods give different weights to each of these. Some, for instance, ignore point two and treat children as being equivalently costly as adults.

From a theoretical point of view, we could adjust either income or expenditure to take these into account. However, normal practice is to adjust income to reflect all three points.

The economic concept underlying point three is economies of scale in consumption.

Economies of scale in consumption at the household level arise in part from sharing infrastructure (for example, vehicles, and internet, gas, and electricity connections). Such economies directly affect household expenditure on infrastructure services, and thus are already present in our expenditure data. So, applying an adjustment to income data risks double counting. Accordingly, we have decided not to present our results using equivalised household income.

The regressions found in the paper are another way of examining the effects of income while controlling for household characteristics.

## A. 3. Disposable income quintiles

We rank households by disposable income, then split these into five equal-size groups (i.e., quintiles). We do this separately for each survey year, so quintile one (for example) in the pooled dataset is the union of all quintile one households across all five survey waves.

## A. 4. Interpreting disposable income quintiles

A natural interpretation is that quintile one represents 'the poor', whereas quintile five represents 'the rich'. There are a few wrinkles on this interpretation, however. First, households come in different sizes. Second, some households have substantial 'income' that is missed by household income/expenditure

surveys, for example the value that arises from asset use (for example, living in a house they own). Third, households tend to save during periods of higher income (as financial or physical assets) and draw down (or run down) those assets during periods of lower income.

## A. 5. Categorising houses by income class

To investigate the issues above, we split households into five income classes, based on their primary source of household income.[22]

Table 10: Income classes

| Income class | Label | Description |
|---|---|---|
| 1 | Retired | Non-zero NZ Super or KiwiSaver income; more than half household income from these sources, other government transfers or investments |
| 2 | Welfare dependent | Non-zero income from core benefits income; more than half household income from these sources or other government transfers |
| 3 | Student | Either: (a) non-zero income from student allowance; more than half household income from student allowance or other government transfers; or (b) not Retired; and no one over 18 and in full-time employment; and at least one person over 18 and under 65 is studying at a tertiary institution. |
| 4 | Employed | Not retired, more than half income is from employment (for example, wages) |
| 5 | Other (investment or mixed) | Does not meet criteria for 1-4. Typically, more than half income is from investments, or the household has mixed income sources |

## A. 6. Categorising New Zealand households

Retired, welfare-dependant and student households are strongly skewed towards the low-income quintiles. Employment-dependent households are skewed towards the middle and high quintiles. The 'other' income class is mildly skewed towards low-income quintiles.

Table 11 below shows how the households in our dataset are divided between the income classes and disposable income quintiles. The row mean shows the percentage of households in the sample that fit into that income class. Employed households dominate overall (67%), then retired households (21%) and welfare-dependent households (7%). Other household types account for the remainder (5%).

Retired, welfare-dependant and student households are strongly skewed towards the low-income quintiles. Employment-dependent households are skewed towards the middle and high quintiles. The 'other' income class is mildly skewed towards low-income quintiles.

[22] Strictly speaking, the student household class is not solely based on income. On income criteria alone we found relatively few households. We widened the criteria to include households with full-time study and income from part-time employment.

Table 11: How income classes fit into income quintiles

| % of households in cell | Disposable income quintile | | | | | |
|---|---|---|---|---|---|---|
| Household income class | 1 | 2 | 3 | 4 | 5 | Row Mean |
| Retired | 10.4% | 6.8% | 2.4% | 0.9% | 0.8% | *21.4%* |
| Welfare dependent | 4.5% | 1.9% | 0.3% | S | S | *6.8%* |
| Student | 0.9% | 0.7% | 0.3% | S | S | *2.0%* |
| Employed | 3.5% | 9.8% | 16.3% | 18.4% | 18.6% | *66.5%* |
| Other (investment or mixed) | 0.8% | 0.8% | 0.7% | 0.6% | 0.6% | *3.4%* |

## A. 7. Is household income sufficient to cover their expenditure?

Household income can be volatile from year-to-year. Individual households, to varying degrees, can manage this volatility by saving (for example, financial savings, accruing and improving physical assets, investing in human capital, repaying debt) and dis-saving (for example, drawing down financial savings, selling physical assets, deferring maintenance, increasing debt).

Can we see evidence of saving or dis-saving in the HES data? To what extent is current household income sufficient to cover current household expenses? To investigate this question, we created a measure of household expenditure that excluded large financial and capital transactions (for example, KiwiSaver deposits, buying and selling houses and vehicles). Dividing disposable income by this 'non-capital expenditure' gives us an 'expenditure coverage' ratio. A ratio below 100% means the household drawing down their financial savings or assets, whereas a ratio above 100% means the household is saving.

The following table shows mean expenditure coverage by household income class and by disposable-income quintile. Numbers with coverage less than or equal to 95% are shaded red. These households are, on average, drawing down on their savings. This is predictable and does not necessarily constitute a problem for retired and student households. But it is of more concern for welfare-dependent households, and for low-income employed households.[23]

Numbers with better than 105% coverage are shaded green; these households are, on average, increasing their savings. Numbers between 95% and 105% are unshaded, as it could be misleading to draw strong conclusions about coverage numbers just below or just above 100%.

Table 12: Expenditure coverage for households in each income class and income quintile

| Mean expenditure coverage | Disposable income quintile | | | | | |
|---|---|---|---|---|---|---|
| Household income class | 1 | 2 | 3 | 4 | 5 | Row Mean |
| Retired | 95% | 101% | 119% | 126% | 183% | 104% |
| Welfare dependent | 87% | 103% | 129% | S | S | 93% |
| Student | 63% | 87% | 93% | S | S | 77% |
| Employed | 67% | 98% | 113% | 130% | 157% | 125% |
| Other (investment or mixed) | 49% | 80% | 99% | 107% | 187% | 100% |
| Mean expenditure coverage | 85% | 98% | 113% | 129% | 159% | |

*Red numbers are less than 95%, black numbers are between 95 and 100%, and green numbers are more than 105%.*

[23] While expenditure cannot exceed income in the long term for a single household, this can be the case for a cross-section of households at a point in time. From a welfare policy perspective, it would be useful to know the persistence of welfare dependence and low-income employment at a household level. That is beyond the scope of this project.

## A. 8. Difficulty paying bills

The HES surveys for 2012/13, 2015/16 and 2018/19 ask respondents whether they have had difficulty paying bills in the past 12 months.[24] The following table breaks down those responses by household income class and by disposable-income quintile.

Table 13: Percent of households in each income class and disposable income quintile that reported difficulty paying infrastructure bills

| % households reporting difficulty paying infra bills[25] | Disposable income quintile | | | | | |
|---|---|---|---|---|---|---|
| Household income class | 1 | 2 | 3 | 4 | 5 | Row Mean |
| Retired | 3% | 3% | S | S | S | 2% |
| Welfare dependent | 34% | 40% | 42% | S | S | 36% |
| Student | 29% | 19% | S | S | S | 21% |
| Employed | 13% | 13% | 10% | 6% | 3% | 7% |
| Other (investment or mixed) | 0% | 0% | 0% | 0% | 0% | 0% |
| Column mean | 12% | 12% | 9% | 5% | 2% | 8% |

The responses to this question are inconsistent with the results reported above. For the population as a whole, and employed households in particular, difficulty paying bills does not diminish quickly with income. A preliminary hypothesis, which would need to be tested with better data, is that difficulty (as measured here) is more dependent on budgeting skills than income; and it only reduces substantially once the bills involved represent a small proportion of total household income. An apparent anomaly is that reported difficulty paying bills rises with income quintile for welfare-dependent households. A tentative hypothesis would be that the combination of welfare-dependence and higher-income quintiles may reflect large numbers of household members, with relatively low per-person incomes and higher household budget coordination costs.

Difficulty paying bills is consistently low for retired households.

## A. 9. Understanding household assets

The HES expenditure sub-sample contains little data on household assets. It does, however, identify which household are renting vs. those who own the dwelling they live in.

Overall, 68% of households are owners. This ranges from 84% for retired households, down to 18% for student households. Home-ownership rates are more than 50% across all income quintiles, showing that income by itself is probably a poor proxy for low household assets.

[24] The HES asks two questions, each about different types of infrastructure services bills. Respondents can choose no difficulty, difficulty once, or difficulty two or more times. ('Difficulty' includes both shortage of money and late payment for any reason.) We record a household as having difficulty if they report difficulty two or more times for either question, or they report difficulty once for both questions.

[25] These proportions are estimated, rather than measured, as the relevant questions were not asked in the 2006/07 and 2009/10 surveys.

Table 14: Percent of households in each income class and disposable income quintile that own the dwelling they live in

| % households owning dwelling they live in | Disposable income quintile | | | | | |
|---|---|---|---|---|---|---|
| Household income class | 1 | 2 | 3 | 4 | 5 | Row Mean |
| Retired | 77% | 88% | 95% | 94% | S | 84% |
| Welfare dependent | 27% | 19% | 24% | S | S | 24% |
| Student | 16% | 18% | 24% | S | S | 18% |
| Employed | 53% | 53% | 62% | 71% | 82% | 68% |
| Other (investment or mixed) | 63% | 73% | 74% | 70% | 88% | 73% |
| Column mean | 58% | 61% | 65% | 72% | 82% | 68% |

## A. 10. Infrastructure spending by income class and disposable-income quintile

As a proportion of disposable income, the spending patterns of households in each income class do not vary significantly from the overall population means.

Table 15: Mean percentage of disposable income spent on infrastructure services by income class and disposable income quintile

| Mean % disposable income spent on infrastructure services | Disposable income quintile | | | | | |
|---|---|---|---|---|---|---|
| Household income class | 1 | 2 | 3 | 4 | 5 | Row Mean |
| Retired | 34% | 28% | 21% | 16% | 10% | 29% |
| Welfare dependent | 35% | 26% | 23% | S | S | 32% |
| Student | 40% | 30% | 23% | S | S | 34% |
| Employed | 40% | 26% | 21% | 17% | 12% | 19% |
| Other (investment or mixed) | 48% | 30% | 22% | 20% | 8% | 27% |
| Column mean | 36% | 27% | 21% | 17% | 11% | 17% |

# Appendix B: Kernel density estimator

The kernel density plots are estimated using the Epanechnikov kernel function (Epanechnikov, 1969). Kernel density plots are a way of estimating the distribution f(x) from observations on x. Kernel density plots are similar to histogram bar graphs. Histograms divide the data into nonoverlapping intervals and count the number of datapoints in each interval. With a kernel density plot, the data is still divided into intervals, but these intervals are allowed to overlap. Rather than merely counting the number of observations in the interval, the kernel density estimator weights the observations based on how far they are from the centre of the interval. The result is a smoothed distribution that is independent of the choice of origin (the choice of origin for a histogram is where you put the beginning and end of each interval).

The kernel density estimate is formed by summing the weighted values calculated with the general kernel function $K$:

$$\widehat{f_K} = \frac{1}{qh}\sum_{i=1}^{n} w_i K\left(\frac{x - x_i}{h}\right)$$

Where $w_i$ is the weight for observation $i$, $h > 0$ is the bandwidth and $q = \sum_i w_i$. With an Epanechnikov kernel function:

$$K[z] = \begin{cases} \frac{3}{4}\left(1 - \frac{1}{5}z^2\right)/\sqrt{5} & if\ |z| < 1 \\ 0 & otherwise \end{cases}$$

Kernel density estimates are smoothed and do not adhere to data ranges which can result in portions of the distribution being nonsensical. It is not feasible that people spend a negative proportion of their income on infrastructure services, nor do we believe that people are spending over 100% of their income on infrastructure services.

# Appendix C: Full regression results

## A. 11. Econometric methods overview

In this Appendix we present regression results which examine the relationship between household characteristics and household expenditure on infrastructure services. First, we present expenditure elasticities with respect to income. This is done by taking the natural logarithm of the dependent variable and the natural logarithm of the income independent variable. Expenditure elasticities can be interpreted as 'a 1% increase in income is estimated to result in an *x*% increase in expenditure on the good or service in question'. The expenditure elasticities are calculated using ordinary least squares (OLS) regression.

The elasticity regressions can be defined by the following equation,

$$Log(x) = \log(after\ tax\ income)'\beta + Z'\alpha$$

Where $x$ is the dependent variable, β is estimated effect of after-tax income on the dependent variable, $Z$ is a vector of controls and α is the vector of coefficients on the controls. B is the expenditure elasticity which can be interpreted as outlined above. The α values are semi-elasticities. These can be interpreted as 'a one unit increase in the $Z$ control is estimated to increase expenditure on the dependent variable $x$ by 100 × α percent'.

However, for the variable component of infrastructure spending, there is often a significant number of zeros in the data as households do not utilise every service. This is especially true for public transport where most households do not use it and therefore spend nothing on the variable component of public transport spending. The presence of these zeros means that OLS regression models are not appropriate. A linear OLS model is inappropriate for multiple reasons. Firstly, it ignores that the dependent variable cannot be negative. Second, the assumption of constant marginal effects is inappropriate when the dependent variable is bounded from below. Third, it is impossible to impose non-negativity and non-constant marginal effects by log-transforming the dependent variable as the log of zero is undefined. And fourth, any purely continuous distribution (such as a normal distribution) does not account for the cluster at zero.

Therefore, we use Cragg's truncated normal hurdle model (Cragg, 1971). This model contains two parts. The first is a participation decision mechanism (the hurdle) where the household decides whether it wants to purchase some of a good. For example, the household decides whether or not it wants to use public transport. The second part is then the amount decision mechanism, where the household decides how much of the good it wants to purchase. For the public transport example, the household decides how often it wants to make use of public transport. Cragg's truncated normal hurdle model assumes that the participation decision follows a probit model and that the latent amount decision follows a truncated normal distribution.

The coefficients in the hurdle model are in levels, therefore are interpreted as simply 'a one unit increase in the dependent variable is estimated to increase the independent variable by β units' where β is the coefficient.

Table 16: OLS, expenditure elasticities with respect to income for infrastructure services

| Dependent variable | Log (all expenditure) | Log (all expenditure) | Log (variable expenditure) | Log (private vehicle) | Log (variable private vehicle) |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Log (income after-tax) | 0.428*** | 0.242*** | 0.306*** | 0.294*** | 0.289*** |
| | (0.005) | (0.006) | (0.010) | (0.011) | (0.017) |
| Number of adults | | 0.201*** | 0.210*** | 0.302*** | 0.194*** |
| | | (0.004) | (0.007) | (0.008) | (0.012) |
| Number of children | | 0.049*** | 0.090*** | 0.050*** | 0.057*** |
| | | (0.003) | (0.005) | (0.006) | (0.008) |
| Working | | 0.113*** | 0.254*** | 0.229*** | 0.229*** |
| | | (0.009) | (0.015) | (0.016) | (0.025) |
| Renting | | -0.111*** | -0.099*** | -0.188*** | -0.054*** |
| | | (0.007) | (0.012) | (0.013) | (0.020) |
| Small regional centre | | -0.027 | -0.068** | -0.049 | -0.085* |
| | | (0.017) | (0.029) | (0.032) | (0.049) |
| Medium regional centre | | -0.056*** | -0.117*** | -0.083*** | -0.218*** |
| | | (0.015) | (0.025) | (0.027) | (0.042) |
| Large regional centre | | -0.056*** | -0.105*** | -0.067*** | -0.178*** |
| | | (0.012) | (0.020) | (0.022) | (0.034) |
| Metro and PDQ 1 | | 0.043** | 0.028 | -0.009 | 0.010 |
| | | (0.017) | (0.029) | (0.032) | (0.047) |
| Metro and PDQ 2 | | -0.008 | -0.077*** | -0.106*** | -0.146*** |
| | | (0.014) | (0.024) | (0.026) | (0.040) |
| Metro and PDQ 3 | | -0.009 | -0.083*** | -0.113*** | -0.174*** |
| | | (0.013) | (0.023) | (0.025) | (0.037) |
| Metro and PDQ 4 | | -0.012 | -0.101*** | -0.157*** | -0.199*** |
| | | (0.012) | (0.021) | (0.023) | (0.035) |
| Metro and PDQ 5 | | -0.019 | -0.156*** | -0.176*** | -0.184*** |
| | | (0.012) | (0.020) | (0.022) | (0.034) |
| $R^2$ | 0.340 | 0.442 | 0.312 | 0.311 | 0.124 |
| Observations | 16008 | 16008 | 15915[26] | 16008 | 13332 |

*Standard errors in parentheses, *** = p<0.01, ** = p<0.05, * = p<0.1.*

[26] Where the observation count is less than 16,008 there is a selection issue in the model as households with zero expenditure in the dependent variable of interest are dropped when taking the natural logarithm of the dependent variable. The lower the observation count, the more likely the bias is to be severe.

Table 16: OLS, expenditure elasticities with respect to income for infrastructure services (continued)

| Dependent variable | Log (public transport) | Log (variable public transport)[27] | Log (electricity) | Log (variable electricity) | Log (fibre and copper telecoms) |
|---|---|---|---|---|---|
| | (6) | (7) | (8) | (9) | (10) |
| Log (income after-tax) | 0.371*** | 0.182*** | 0.110*** | 0.113*** | 0.143*** |
| | (0.013) | (0.058) | (0.009) | (0.010) | (0.011) |
| Number of adults | 0.156*** | 0.106*** | 0.161*** | 0.182*** | 0.050*** |
| | (0.010) | (0.035) | (0.007) | (0.007) | (0.008) |
| Number of children | 0.038*** | 0.023 | 0.094*** | 0.105*** | 0.022*** |
| | (0.007) | (0.027) | (0.005) | (0.005) | (0.005) |
| Working | 0.000 | 0.419*** | 0.011 | 0.015 | 0.095*** |
| | (0.019) | (0.111) | (0.013) | (0.014) | (0.015) |
| Renting | -0.018 | 0.164** | -0.077*** | -0.098*** | -0.021* |
| | (0.015) | (0.067) | (0.011) | (0.011) | (0.012) |
| Small regional centre | 0.125*** | 0.787* | -0.064** | -0.059** | -0.053* |
| | (0.039) | (0.429) | (0.027) | (0.028) | (0.030) |
| Medium regional centre | 0.102*** | -0.111 | -0.087*** | -0.064*** | -0.004 |
| | (0.033) | (0.278) | (0.023) | (0.024) | (0.026) |
| Large regional centre | -0.240*** | -0.519** | -0.096*** | -0.100*** | -0.019 |
| | (0.027) | (0.227) | (0.019) | (0.020) | (0.021) |
| Metro and PDQ 1 | 0.705*** | 0.145 | 0.049* | 0.050* | 0.015 |
| | (0.039) | (0.241) | (0.027) | (0.028) | (0.030) |
| Metro and PDQ 2 | 0.805*** | 0.237 | -0.091*** | -0.090*** | 0.036 |
| | (0.032) | (0.217) | (0.022) | (0.024) | (0.025) |
| Metro and PDQ 3 | 0.840*** | 0.225 | -0.108*** | -0.121*** | -0.029 |
| | (0.030) | (0.214) | (0.021) | (0.022) | (0.023) |
| Metro and PDQ 4 | 0.965*** | 0.155 | -0.108*** | -0.122*** | -0.023 |
| | (0.028) | (0.207) | (0.019) | (0.020) | (0.022) |
| Metro and PDQ 5 | 1.343*** | 0.163 | -0.193*** | -0.197*** | -0.052** |
| | (0.027) | (0.204) | (0.019) | (0.020) | (0.021) |
| $R^2$ | 0.406 | 0.070 | 0.139 | 0.150 | 0.060 |
| Observations | 15960 | 1866 | 14745 | 14604 | 14046 |

*Standard errors in parentheses, *** = p<0.01, ** = p<0.05, * = p<0.1.*

[27] Note the very low observation count. This regression is likely to be biased. The geographic controls are most likely to be incorrect as nearly all rural households will be dropped from the sample. The regression results here would imply that metropolitan households do not spend more than rural households on public transport, whereas those in large regional centres do. This is not likely and not supported by the full public transport expenditure (fixed + variable) regression, nor by the selection model regression.

Table 16: OLS, expenditure elasticities with respect to income for infrastructure services (continued)

| Dependent variable | Log (variable fibre and copper) | Log (mobile telecoms) | Log (variable mobile telecoms) | Log (reticulated gas) | Log (household heating fuels) |
|---|---|---|---|---|---|
| | (11) | (12) | (13) | (14) | (15) |
| Log (income after-tax) | 0.250*** | 0.225*** | 0.210*** | 0.143*** | 0.201*** |
| | (0.024) | (0.022) | (0.022) | (0.032) | (0.032) |
| Number of adults | 0.090*** | 0.091*** | 0.080*** | 0.065*** | 0.042* |
| | (0.017) | (0.015) | (0.014) | (0.023) | (0.023) |
| Number of children | 0.038*** | 0.024** | 0.024** | 0.070*** | 0.073*** |
| | (0.012) | (0.011) | (0.010) | (0.016) | (0.015) |
| Working | 0.280*** | 0.221*** | 0.231*** | -0.034 | -0.200*** |
| | (0.036) | (0.037) | (0.035) | (0.052) | (0.050) |
| Renting | 0.221*** | 0.214*** | 0.223*** | -0.094** | -0.190*** |
| | (0.028) | (0.025) | (0.024) | (0.044) | (0.039) |
| Small regional centre | -0.165** | -0.044 | -0.029 | 0.053 | 0.018 |
| | (0.070) | (0.067) | (0.065) | (0.126) | (0.090) |
| Medium regional centre | -0.253*** | -0.048 | -0.076 | 0.114 | 0.131* |
| | (0.059) | (0.059) | (0.056) | (0.122) | (0.075) |
| Large regional centre | -0.107** | -0.052 | -0.045 | 0.193** | -0.010 |
| | (0.048) | (0.046) | (0.044) | (0.102) | (0.060) |
| Metro and PDQ 1 | -0.170** | -0.006 | 0.037 | 0.108 | -0.218** |
| | (0.068) | (0.064) | (0.062) | (0.149) | (0.084) |
| Metro and PDQ 2 | -0.110* | -0.054 | -0.081 | 0.152 | 0.023 |
| | (0.057) | (0.054) | (0.052) | (0.114) | (0.072) |
| Metro and PDQ 3 | -0.201*** | -0.028 | -0.034 | 0.120 | -0.113 |
| | (0.053) | (0.050) | (0.048) | (0.105) | (0.069) |
| Metro and PDQ 4 | -0.186*** | 0.050 | 0.054 | 0.158 | -0.068 |
| | (0.049) | (0.047) | (0.045) | (0.102) | (0.065) |
| Metro and PDQ 5 | -0.067 | 0.060 | 0.070 | 0.049 | -0.244*** |
| | (0.048) | (0.045) | (0.043) | (0.103) | (0.065) |
| $R^2$ | 0.074 | 0.079 | 0.084 | 0.046 | 0.021 |
| Observations | 9024 | 6279 | 6063 | 2049 | 7572 |

*Standard errors in parentheses, *** = p<0.01, ** = p<0.05, * = p<0.1.*

Table 17: Cragg's truncated normal hurdle model, estimated marginal effect on expenditure on dependent variable

| Dependent variable | Variable private transport | Variable public transport | Variable fibre and copper telecoms | Variable mobile telecoms | Variable electricity |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Income after-tax ($000s) | 8.64*** | 0.25** | 1.04*** | 1.16*** | 1.49*** |
| | (0.69) | (0.11) | (0.16) | (0.11) | (0.20) |
| Number of adults | 1079.26*** | 69.31*** | 92.24*** | 102.26*** | 335.36*** |
| | (47.75) | (7.64) | (10.71) | (7.75) | (13.91) |
| Number of children | 317.93*** | 14.54*** | 30.69*** | 25.74*** | 181.24*** |
| | (32.58) | (5.50) | (7.63) | (5.60) | (9.90) |
| Working | 1547.96*** | 116.33*** | 257.15*** | 244.04*** | 109.59*** |
| | (71.11) | (11.43) | (15.80) | (11.98) | (24.74) |
| Renting | -531.16*** | 56.33*** | 29.84* | 134.47*** | -238.71*** |
| | (71.67) | (14.65) | (18.04) | (14.39) | (21.13) |
| Small regional centre | -292.17 | 19.28 | -83.64* | -1.15 | -64.29 |
| | (207.18) | (28.94) | (44.30) | (33.43) | (58.82) |
| Medium regional centre | -801.41*** | 9.10 | -130.91*** | -56.27** | -64.69 |
| | (164.95) | (15.06) | (36.55) | (26.99) | (49.90) |
| Large regional centre | -628.55*** | -1.24 | -32.30 | 10.51 | -197.04*** |
| | (142.78) | (10.88) | (32.98) | (22.97) | (41.45) |
| Metro and PDQ 1 | 279.59 | 124.81*** | -77.36* | 11.22 | 164.01*** |
| | (218.02) | (29.53) | (43.72) | (33.15) | (62.76) |
| Metro and PDQ 2 | -418.64** | 207.84*** | -58.02 | -22.62 | -168.02*** |
| | (167.72) | (28.98) | (38.25) | (26.37) | (48.67) |
| Metro and PDQ 3 | -540.68*** | 176.12*** | -89.09** | 9.73 | -230.36*** |
| | (155.61) | (24.01) | (34.81) | (25.25) | (45.04) |
| Metro and PDQ 4 | -708.16*** | 207.17*** | -67.23** | 50.61** | -226.58*** |
| | (145.96) | (21.50) | (33.20) | (24.43) | (42.34) |
| Metro and PDQ 5 | -725.75*** | 213.16*** | -54.25 | 40.60* | -351.00*** |
| | (142.15) | (19.91) | (33.05) | (23.43) | (40.22) |
| Observations | 16,008 | 16,008 | 16,008 | 16,008 | 16,008 |

*Standard errors in parentheses, *** = p<0.01, ** = p<0.05, * = p<0.1.*

Table 17: Cragg's truncated normal hurdle model, estimated marginal effect on expenditure on dependent variable (continued)

| Dependent variable | Variable reticulated gas | Variable household heating fuels |
|---|---|---|
| | (6) | (7) |
| Income after-tax ($000s) | 0.54*** | 0.92*** |
| | (0.06) | (0.11) |
| Number of adults | 20.95*** | 36.59*** |
| | (4.57) | (7.32) |
| Number of children | 23.60*** | 43.70*** |
| | (3.43) | (5.15) |
| Working | 6.46 | 32.63** |
| | (9.07) | (14.12) |
| Renting | -58.88*** | -117.58*** |
| | (6.83) | (10.66) |
| Small regional centre | 61.94*** | -20.88 |
| | (16.98) | (34.02) |
| Medium regional centre | 41.51*** | 18.70 |
| | (13.25) | (30.57) |
| Large regional centre | 99.34*** | -10.66 |
| | (11.63) | (23.31) |
| Metro and PDQ 1 | 12.18 | -83.35*** |
| | (12.85) | (28.16) |
| Metro and PDQ 2 | 59.35*** | -24.50 |
| | (13.32) | (27.32) |
| Metro and PDQ 3 | 86.38*** | -94.09*** |
| | (12.55) | (23.81) |
| Metro and PDQ 4 | 105.32*** | -92.14*** |
| | (12.07) | (22.92) |
| Metro and PDQ 5 | 64.31*** | -164.38*** |
| | (10.01) | (21.27) |
| Observations | 16,008 | 16,008 |

*Standard errors in parentheses, *** = p<0.01, ** = p<0.05, * = p<0.1.*

Table 18: Cragg's truncated normal hurdle model, estimated marginal effect on probability of consuming dependent variable

| Dependent variable | Variable private transport | Variable public transport | Variable fibre and copper telecoms | Variable mobile telecoms | Variable electricity |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Income after-tax ($000s) | 0.0002*** | 0.0001*** | 0.0000 | 0.0005*** | -0.0002*** |
| | (0.0001) | (0.0000) | (0.0001) | (0.0001) | (0.0000) |
| Number of adults | 0.065*** | 0.034*** | 0.027*** | 0.059*** | -0.002 |
| | (0.004) | (0.003) | (0.005) | (0.005) | (0.003) |
| Number of children | 0.025*** | 0.007*** | 0.007* | 0.014*** | -0.004* |
| | (0.003) | (0.002) | (0.004) | (0.004) | (0.002) |
| Working | 0.136*** | 0.045*** | 0.092*** | 0.154*** | 0.008 |
| | (0.008) | (0.006) | (0.010) | (0.009) | (0.006) |
| Renting | -0.068*** | 0.026*** | -0.083*** | 0.044*** | -0.029*** |
| | (0.007) | (0.006) | (0.009) | (0.008) | (0.005) |
| Small regional centre | -0.001 | -0.010 | 0.006 | 0.009 | 0.020* |
| | (0.015) | (0.007) | (0.022) | (0.021) | (0.012) |
| Medium regional centre | 0.000 | 0.012 | 0.008 | -0.030 | 0.025** |
| | (0.013) | (0.008) | (0.019) | (0.018) | (0.010) |
| Large regional centre | 0.000 | 0.020*** | 0.025* | 0.025* | -0.011 |
| | (0.011) | (0.006) | (0.015) | (0.015) | (0.009) |
| Metro and PDQ 1 | 0.035** | 0.085*** | 0.012 | -0.005 | 0.026** |
| | (0.015) | (0.012) | (0.022) | (0.021) | (0.011) |
| Metro and PDQ 2 | 0.015 | 0.130*** | -0.003 | 0.003 | -0.006 |
| | (0.013) | (0.011) | (0.018) | (0.017) | (0.011) |
| Metro and PDQ 3 | 0.014 | 0.109*** | 0.015 | 0.018 | -0.010 |
| | (0.012) | (0.009) | (0.017) | (0.016) | (0.010) |
| Metro and PDQ 4 | -0.010 | 0.142*** | 0.033** | 0.022 | -0.007 |
| | (0.011) | (0.009) | (0.016) | (0.015) | (0.009) |
| Metro and PDQ 5 | -0.024** | 0.146*** | -0.020 | 0.006 | -0.007 |
| | (0.011) | (0.008) | (0.015) | (0.015) | (0.009) |
| Observations | 16008 | 16008 | 16008 | 16008 | 16008 |

*Standard errors in parentheses, *** = p<0.01, ** = p<0.05, * = p<0.1.*

Table 18: Cragg's truncated normal hurdle model, estimated marginal effect on probability of consuming dependent variable (continued)

| Dependent variable | Variable reticulated gas | Variable household heating fuels |
|---|---|---|
| | (6) | (7) |
| Income after-tax ($000s) | 0.0005*** | 0.0005*** |
| | (0.0000) | (0.0001) |
| Number of adults | 0.009*** | 0.035*** |
| | (0.003) | (0.005) |
| Number of children | 0.009*** | 0.036*** |
| | (0.002) | (0.004) |
| Working | 0.000 | 0.112*** |
| | (0.007) | (0.010) |
| Renting | -0.055*** | -0.116*** |
| | (0.005) | (0.008) |
| Small regional centre | 0.071*** | -0.057*** |
| | (0.013) | (0.022) |
| Medium regional centre | 0.039*** | -0.048** |
| | (0.009) | (0.018) |
| Large regional centre | 0.101*** | -0.021 |
| | (0.008) | (0.015) |
| Metro and PDQ 1 | 0.004 | -0.015 |
| | (0.009) | (0.022) |
| Metro and PDQ 2 | 0.053*** | -0.050*** |
| | (0.009) | (0.018) |
| Metro and PDQ 3 | 0.098*** | -0.099*** |
| | (0.009) | (0.017) |
| Metro and PDQ 4 | 0.112*** | -0.127*** |
| | (0.009) | (0.016) |
| Metro and PDQ 5 | 0.078*** | -0.188*** |
| | (0.008) | (0.015) |
| Observations | 16008 | 16008 |

*Standard errors in parentheses, *** = p<0.01, ** = p<0.05, * = p<0.1.*