TE MANATŪ WAKA
MINISTRY OF TRANSPORT

The Distributional Impacts of Transport-related Carbon Policy | Ngā Pāpātanga Tuari o te Tikanga Here Waro e pā ana ki te Waka

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Transport Evidence Base report

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For more information

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MINISTRY OF TRANSPORT

Research, Economics and Evaluation

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

The team is responsible for:

- Providing sector direction on the establishment and use of the Transport Evidence Base (see below)– including the collection, use, and sharing of data, research and analytics across the transport sector and fostering the development of sector research capabilities and ideas.
- Leading and undertaking economic analyses, appraisals and assessment including providing economic input on business cases and funding requests.
- Performing the evaluation function for the Ministry, including designing monitoring and evaluation frameworks and approaches, developing performance metrics and indicators, and designing, conducting and procuring evaluations.

The Transport Evidence Base

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

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1 Introduction

This is a report prepared for Te Manatū Waka the Ministry of Transport on the *Distributional Impacts of Transport-related Carbon Policy*. Te Manatū Waka commissioned this research to explore whether and how accessibility and mobility inequalities affect access to economic, social and other opportunities for different population groups according to different household, individual and location characteristics. This level of analysis requires access to various administrative datasets available through Statistics New Zealand's Data Labs with its Integrated Data Infrastructure (IDI). This research includes two components:

- a literature review on methods for assessing, and findings of, the distributional impacts of climate change or climate policy by user type and other characteristics; and
- an investigation, using data from the IDI, into the interrelationships between transport and housing costs, commuting needs, access to jobs and other opportunities and hence with emissions outcomes, by household income and other characteristics.

As most policies do, policies to address climate change will generally have economic impacts which can be distributed disproportionately across the population. There has been a large focus on the economic effects of these policies as well as on the potential distributional impacts on the affected groups. One main focus has been on the differential effects carbon pricing policies will have on households, particularly on lower-income households, as carbon pricing policies have been deemed an "indispensable" part of strategies to reduce carbon emissions efficiently in order to mitigate the effects of climate change (High-Level Commission on Carbon Prices, 2017). The distributional impacts of other non-price interventions have also been assessed but on a more limited basis.

Carbon pricing policies are designed to correct market failures related to negative externalities associated with fossil fuel consumption (e.g., pollution, carbon dioxide concentration in the atmosphere) which generally cause suppliers to set prices below socially optimal values and buyers to overconsume these fuels. Carbon taxes are designed to price these negative externalities such that buyers' decisions more accurately reflect the true cost of their decisions (Stiglitz, 2019).

While this may improve efficiency and resource allocation towards a more socially optimal state, fossil fuels are an integral component of daily life for households and businesses, especially in developed countries, and households have optimised their consumption decisions based on current prices. Increasing the cost of fossil fuels, then, impacts households directly by increasing the cost of energy used in the home and their cost of transport. In addition, these increases also impact households indirectly by increasing the cost of other goods as businesses also adjust to higher input prices. Higher-income households can generally absorb these cost increases in the short run and afford to substitute away from fossil fuels (e.g., purchase new, fuel-efficient vehicles; move closer to their jobs) in the longer run. Lower-income households, on the other hand, often have more difficulties adapting to price increases, causing them to be disproportionately impacted. Hence, these policies often face popular resistance.

The yellow-vest protests in France are a recent, though not unique, example of resistance to carbon taxes and were particularly linked to transport policy. These protests began in 2018 over increasing fuel prices – in particular an additional fee on diesel[1] – and also a reduction in the speed limit for country roads.[2] The protests were disproportionately by rural and peri-urban residents who felt targeted by both the diesel fee and the speed limit changes as these groups rely heavily on private vehicles[3] for transport (Hamdaoui, 2021; Mehleb et al., 2021).

Despite indications by the French government that the taxes were to be recycled to help with the transition and distributional concerns, there was no clear earmarking of these revenues, and many believed that the revenues would instead be used to offset tax cuts that primarily benefited the wealthy which had been instituted around the same time (Mehleb et al., 2021; Stiglitz, 2019). Mehleb et al. (2021) used systematic discourse analysis to assess the viewpoints of active participants in the yellow-vest protests and found common themes of an unfair policy that placed more burden on the unprivileged without addressing these inequalities and no evidence of climate denialism or scepticism despite portrayals of the movement as anti-green.

The yellow-vest protests highlight the importance of considering and clearly communicating the distributional effects of carbon policies in order to gain support for them. After the yellow-vest protests, the French fuel tax was initially suspended but then dropped from the 2019 budget and has not been reinstituted. Moreover, a number of governments implemented tax holidays, particularly related to transport, to reduce the impact on lower-income households as fuel prices have increased sharply in 2022 (Sharafedin et al., 2022). Reinstating these taxes in the future may again require voters' support. Earmarking revenues for environmental measures could be one way to do this as Sælen and Kallbekken (2011) found that this increased support for fuel taxation amongst a representative sample of Norwegian voters

[1] Diesel vehicles were viewed as being more prevalent in lower-income households, so the diesel fees were viewed as targeting these groups.
[2] The speed limit reduction was to increase road safety, not due to carbon policy, but was viewed as another tax imposed via citations on rural populations who rely heavily on their vehicles.
[3] One survey of demonstrators found that 85% reported owning a car (Bedock et al., 2018).

because people expected to personally benefit from their use and that people did not believe that the tax itself would improve environmental quality.[4]

For context, New Zealand households allocate approximately 16% of their total expenditure to transport, which is on the high end relative to other countries as shown in Figure 1. Slovenia has the highest rate (16.9%) compared to the other countries shown in Figure 1.

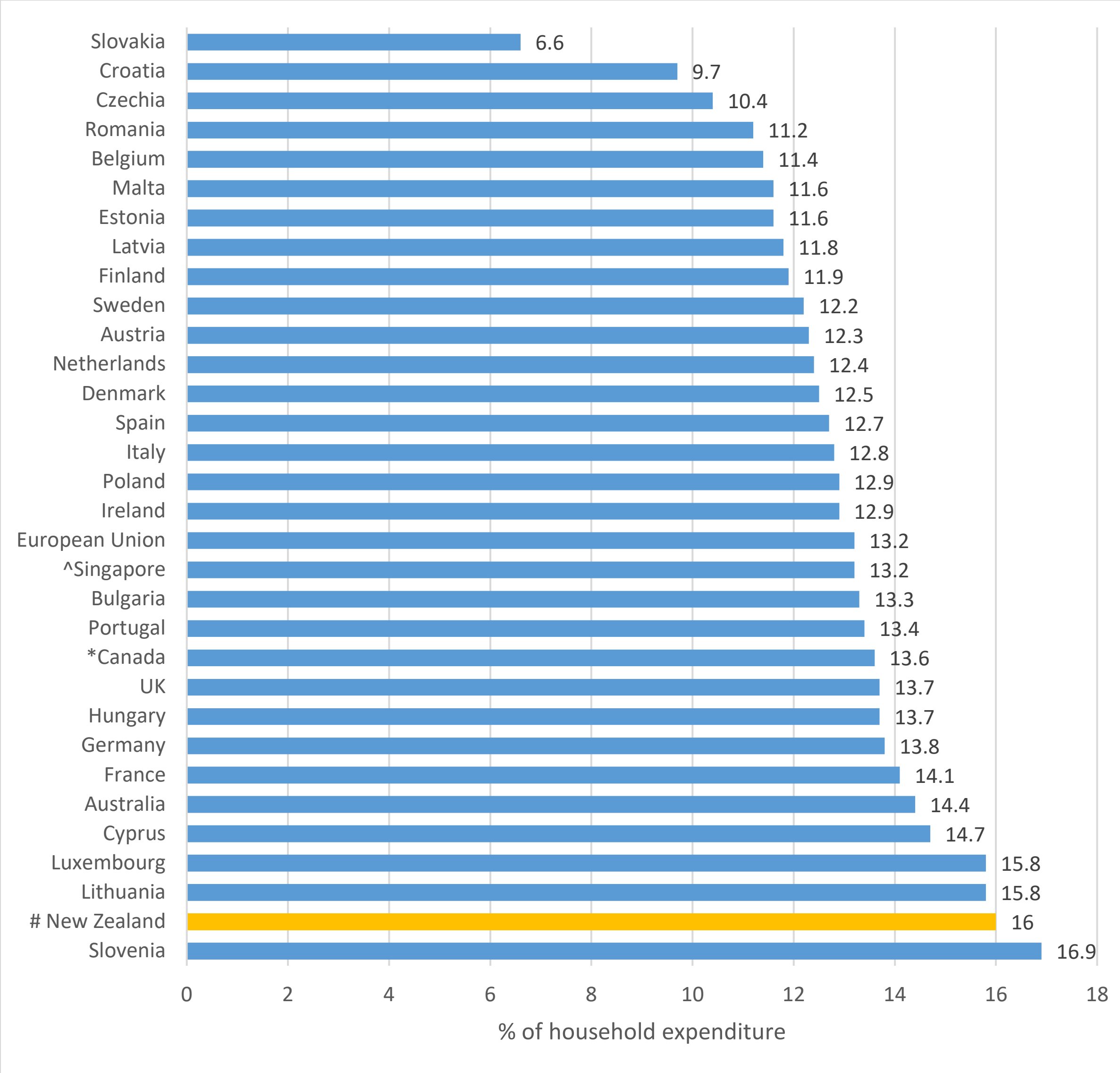


Figure 1: Percentage of Total Household Expenditure Spent on Transport by Country

Notes: ^2017 data; *2019 data; # 2018/19 data

Sources: Data for New Zealand is from Statistics New Zealand; data for Australia is from the Australian Automobile Association (2018); data for Canada is from the NWT Bureau of Statistics (2019); data for Singapore is from the Department of Statistics Singapore (2019); and data for the European countries is from Eurostat (2020).

For this report, we analysed household expenditure data to better understand the following:

[4] Their results also indicated that there was no linkage between increased support for the tax with earmarking and distrust of government. Moreover, the researchers did not find the same increased support for an *income* tax with earmarking for environmental measures.

- the factors driving differences in household transport expenditures, and
- the relationship between households' distance to an economic centre, housing costs and transport expenditures for different household types.

We analysed the latter because the location of low-income housing often means that people who are financially disadvantaged commute longer distances to their jobs with few public transport options (Stiglitz, 2019). Moreover, as fuel prices increase, households may trade off transport costs for housing costs to the extent they can afford to do so, and this adds another dimension to the distributional impacts of carbon policy.

In New Zealand, previous research indicates that low-income households may be trading lower housing costs for higher transport costs. Xiong et al. (2021) found that key workers in Auckland – constrained by budget – had the longest commutes of the workers they analysed.[5] In other research, Mattingly and Morrissey (2014) found that while housing costs in Auckland tended to decline as distance from the city centre increased, measuring affordability using transport costs combined with housing costs changed the pattern of affordability with peripheral areas potentially costing five times more than central neighbourhoods using the combined affordability measure.[6]

While Mattingly and Morrissey (2014) used aggregate data to examine housing affordability when taking transportation costs into account, we used individual household microdata on household and transport expenditures to examine their relationship. Both Mattingly and Morrissey (2014) and Xiong et al. (2021) focused their analysis on Auckland, whereas our analysis includes households across New Zealand.

This report is organised as follows. In the following section, we review the literature related to the distributional effects of transport-related carbon policies, with particular focus on transport-related policies and effects on households. In section 3, we describe our methodology – including the data sources and analytical approaches used. Section 4 presents the results of the analysis, and section 5 concludes.

[5] James (2020) finds that 12% of recent movers aged 20-40 reported that the move was to be closer to work, 30% reported their reason as wanting a bigger house and that a smaller proportion of households reported for moving due to affordability than for house size, quality, and location. However, affordability, house size, quality, and location are often related, and this relationship is seen in reported comments from respondents (e.g., "more for our money, convenient for work", "Better value for money. Bigger section.").

[6] The authors analysed Census data and found that residents living closer to Auckland employment centres generally had fewer vehicles, shorter commutes, fewer commutes using private vehicles.

2 Literature Review

While the project team has reviewed various components of the literature, this section mainly summarises the methods and findings that help inform the investigation using multiple datasets within the IDI.

Much of the literature on the distributional impacts of carbon pricing on households examines the effects fuel price changes are expected to have on household expenditures for household fuels (i.e., energy use in homes) and for household transportation (e.g., petrol, diesel, public transportation prices) in terms of different household characteristics but primarily in terms of income groups (e.g., quintiles). This research tends to focus on determining if carbon policies are likely to be regressive, proportional, or progressive, and hence, these analyses examine the effects of increased fuel prices (generally through the imposition of a fuel tax or through the removal of a fuel subsidy)[7] on households across different income groups.

Wang et al. (2016) provide a review of this literature and report on the general trends. They conclude that studies in developed countries find an overall tendency for regressive impacts of carbon taxes but that the results for developing countries are inconsistent. Moreover, they find that while the carbon tax burden from domestic energy consumption tends to be regressive (with taxes on electricity being more regressive than taxes on heating fuels), the burden from transport fuels is weakly progressive or proportional (tend to place highest burden on middle expenditure deciles) even in developed countries.[8]

Wang et al. (2016) also highlight that policy design can affect both the effectiveness of the tax (in terms of emissions reductions) and its distributional effects. They classify policy measures to reduce adverse effects of the tax as either ex-ante (e.g., lower tax rates or exemptions for the most affected groups) or ex-post (e.g., compensation after the fact as with revenue recycling policies) and note that how the tax is implemented, and its revenue recycled, can weaken or eliminate the initial effects (whether these are regressive or progressive). In their review, they find that energy-intensive industries tend to receive specific exemptions (i.e., ex-ante measures) due to concerns about GDP and labour effects, but this reduces the effectiveness of the tax (in terms of emissions reductions). They state that it is better to incentivise innovation and replacement of emissions-intensive technologies using ex-post measures to reduce adverse effects.[9]

[7] These policy changes may or may not be related to carbon policy.
[8] Sterner (2012) attributes the regressivity argument related to transport fuel taxation to early studies in the U.S.
[9] García-Muros et al. (2022) investigate combining less efficient but more equitable revenue recycling schemes with more efficient but less equitable schemes and find that doing so creates synergies which result in greater efficiency gains and more progressive outcomes.

Wang et al. (2016) find that using lifetime income or expenditure instead of annual income weakens the regressivity. Sterner (2012) also notes that studies using annual disposable income tend to make regressive taxes more regressive and progressive taxes more progressive, whereas total expenditure is considered a better proxy for permanent income.[10] Wang et al. (2016) contend that mitigation can have co-benefits that are typically not included in the distributional impacts analysis. For example, mitigation could also reduce pollution, which tends to disproportionately affect lower-income households and workers. However, the health benefits from reducing pollutants are often not included in distributional studies. One study, Knittel & Sandler (2011), does examine the health co-benefits of carbon pricing in transportation and find that incorporating these benefits resulted in a net benefit (as opposed to a net cost) from fuel taxes between 1998 and 2003 and in a lower net cost between 2004 and 2010.[11] This finding was driven by the fact that increased fuel prices not only reduced the distance households drove but also resulted in households driving newer, cleaner, more efficient vehicles when they did drive.

Studies of developing countries show more inconsistent results with more findings of progressive and proportional impacts in these countries than in developed countries. In developing countries, this could be due to low carbon intensity of poor households' consumption baskets (e.g., cars and fuel are luxury items). Plus, fossil fuel subsidies primarily implemented in developing countries tended to benefit interest groups and disadvantaged low-income households that spend relatively little on energy. Hence, reducing or eliminating these subsidies tend to be progressive in developing countries (Alvarez, 2019; Ohlendorf et al., 2021; Wang et al., 2016).

Given the large number of studies that have been conducted on this topic and the inconsistency of results across studies, two recent articles present the results of meta-analyses[12] which examined the factors affecting whether the study found that the policy was regressive, neutral or proportional, or progressive: Alvarez (2019) and Ohlendorf et al. (2021). These two articles use very similar methods with the primary differences being 1) that Ohlendorf et al. (2021) have more detailed cross-country analyses than Alvarez (2019) and 2) Alvarez (2019) examines the effects of different revenue recycling schemes, whereas Ohlendorf et al. (2021) exclude studies with revenue recycling schemes.

[10] The rationale is that consumption (i.e., expenditure) is smoother than income over an individual's lifetime and hence a more reliable approximation of family welfare (Alvarez, 2019). Sterner (2012) uses both annual disposable income and total expenditure and finds that the results are more regressive when disposable income is used compared to when total expenditure is used as the income measure.
[11] In the latter time period, Knittel & Sandler (2011) estimated the net cost of fuel taxation ranged between \$10-\$25 per ton of CO_2.
[12] Relative to a general literature review, meta-analysis generally has transparent selection and evaluation criteria as well as rigorous methods to analyse observed variation across studies.

These meta-analyses use the factors highlighted in literature reviews such as Wang et al. (2016) to determine the likelihood that a study will find that a policy was regressive, neutral or proportional, or progressive. These studies confirm analytically the general findings of past literature reviews:

- transport policy outcomes relative to economy-wide policy outcomes are more likely to be progressive, even when revenue recycling is not included;
- higher likelihood of progressive outcomes for very poor or unequal (i.e., developing) countries and a higher likelihood of regressive outcomes for wealthier (i.e., developed) countries;
- progressive outcomes are more likely if the study used a measure of permanent income (i.e., expenditure); and
- revenue recycling significantly increases the likelihood of progressive outcomes if done as lump-sum transfer, flat tax discount or food subsidy, but if done as a corporate or income-based tax discount, the effects did not significantly affect the outcome.

Both meta-analyses also examine the effects of the study design itself on the outcome. Alvarez (2019) differentiates studies using general equilibrium modelling from other types of analyses and finds no effect on the results. Moreover, Ohlendorf et al. (2021) find no effect for studies using these types of models specifically, but they do find that studies which included direct and indirect effects and studies which included demand-side effects were both more likely to find progressive outcomes (general equilibrium models often include these types of effects). Ohlendorf et al. (2021) also found that the results from studies of subsidy outcomes were no different than those of cap-and-trade systems or taxation policies.

While most of the previous literature focuses on policies that affect prices, Davis & Knittel (2016) assess the distributional impacts of fuel economy standards.[13] They find that these standards create an implicit subsidy for fuel-efficient vehicles and an implicit tax on fuel-inefficient vehicles. Using ownership patterns of different vehicle types in high- and low-income census tracts in the U.S., they estimate the distributional impacts of these standards. Their results indicate that fuel economy standards in the U.S. are mildly progressive if only new vehicles are considered; however, the standards are regressive with the inclusion of used vehicles, more so than a gasoline tax with lump-sum revenue recycling. Policymakers have tended to prefer fuel economy standards over gasoline taxes, in part due to their view that gasoline taxes are regressive, but these results indicate that an appropriately designed tax policy can be more progressive and more efficient than fuel economy standards.

[13] In the literature, these are often referred to as Corporate Average Fuel Economy (CAFE) standards.

A related literature (Albacete et al., 2017; Boisjoly & El-Geneidy, 2016; Deboosere & Ahmed, 2018; Foth et al., 2013; Savvides, 2013) examines equity and accessibility in transport options – and recently sustainable transport options – which often references the spatial mismatch hypothesis[14] originally proposed in Kain (1968). This literature focuses on the access by certain groups (e.g., women, older adults, ethnic minorities, low income) to transport facilities (Mora et al., 2021). For example, some research has assessed differential access to cycling infrastructure (e.g., bike lanes) as well as differential preferences on the design of that infrastructure. (Buehler & Pucher, 2012; Flanagan et al., 2016; Fraser & Lock, 2011; Hudde, 2022; Lusk et al., 2017; Mackett, 2014; Mackett & Thoreau, 2015; Randal et al., 2022) Standen et al. (2021) report that cycling infrastructure in Sydney is used primarily by higher-income individuals and tends to be more available in denser, urban areas. In examining the health equity of different cycling infrastructure designs, Standen et al. (2021) find that the design could reduce disparities in bicycle accessibility – connected, traffic-free cycleway networks catered to all genders, ages and incomes while a single cycleway most benefited male, high-income, and older age groups. Other research finds that lower-income households have different preferences for the design of the cycling infrastructure (e.g., lower-income households tend to prefer fewer trees due to crime, whereas higher-income households prefer more trees for shade) (Lusk et al., 2017, 2019; Standen et al., 2021). This literature is broad and beyond the scope of this paper; however, Mora et al. (2021) provide an extensive review of the literatures in this area.

[14] Spatial mismatch refers to the mismatch between residential and work locations for minorities. Kain (1992) provides an early review of the literature, and Gobillon et al. (2003) provide a review of the main theoretical models as well as stylised facts related to spatial mismatch in the U.S.

3 Methodology

This section describes the data sources and the analytical approach undertaken for this study.

3.1 Data sources

The main data source for this paper is the Household Economic Survey (HES). The HES is a survey primarily designed to collect itemised household expenditure for calculating the expenditure weights of items in the Consumers Price Index (CPI). Since its inception in 1973, the HES has undergone several redevelopments, most importantly in 2006/07 and 2018/19.[15]

Since the 2006/07 redevelopment, the HES has been run annually with HES Income as the 'core' survey. It is run every year and includes household income, housing costs, and material wellbeing. However, the HES Expenditure is run every three years and includes additional components in an expenditure diary and an expanded household expenditure questionnaire. Since this paper examines transport expenditures, we need data from the expenditure survey. There have been five HES Expenditure surveys since the 2006/07 redevelopment (which generally run from July to June): 2006/07, 2009/10, 2012/13, 2015/16 and 2018/19.[16] We use all five of these surveys in our analysis. For the first four survey cycles, the sample size was 5,000 households, but in 2018/19, the sample size for the detailed expenditure component of the survey was increased to 5,500 households. The response rate was less than 100%; hence, for each year of the survey, we have between 3,000 and 4,000 households for the analysis.

The expenditure component of HES asks respondents about their household expenditures, and in particular their transport and travel expenditures, using both recall and diary data. When the household is interviewed, they are asked about expenditures using a 3-month recall for large or irregular expenditure types (e.g., health, travel); using 12-month recall for housing-related expenditures; and using the latest payment for regular expenditures (e.g., utilities, rates, rent, insurance). All household members aged 15 years and older are also asked to keep a diary record of all their expenditures for a specified period.[17]

[15] The HES was run annually during 1973-1998, then three yearly until 2003/04 and annually from 2006/07. The 2018/19 redevelopment incorporated three major changes. First, income from wages, salaries and benefits are now derived from administrative data rather than collected directly from respondents (Statistics New Zealand, 2020a). Second, in order to get better representation of households with low income or high material deprivation, the sample size for the core HES survey was boosted (to over 21,000, from 3,700 in 2016/17), but the sample size for the expenditure only changed slightly. Third, the weighting scheme also changed. In HES Expenditure years, households now have two weights, one for the expenditure sample and the other for the income sample to reflect the different samples.

[16] There was a continuity break in the survey design that reduces the comparability of data in the years prior to 2006/07. Moreover, earlier years are not currently available for our use in this project. Nevertheless, the available years provide a sufficient sample for us to analyse.

[17] Respondents kept a 14-day diary of expenditures until the 2018/19 survey when the diary was changed to a 7-day diary to reduce respondent burden. More information can be found on the Statistics New Zealand website: https://www.stats.govt.nz/methods/changes-to-the-household-economic-survey-201819.

Generally speaking, transport expenditures are primarily asked via a questionnaire with a 12-month recall (e.g., vehicle purchases, vehicle sales,[18] vehicle repairs, parts, and accessories); however, licensing, registration, and insurance expenditures are asked in terms of the most recent payment and the period covered by that most recent payment. Travel expenditures were separated into those which had a transport component (e.g., air fares, public transport, taxis) and those which did not (e.g., accommodation). For each category of expenditure, we use separate variables to summarise positive and negative expenditures to allow us to distinguish between the two.

In HES, each expenditure item is denoted by the survey module from which it was collected (e.g., transport, travel, housing, diary) as well as a detailed expenditure code from the New Zealand Household Expenditure Classification (NZHEC) which denotes the product or service purchased. Some products or services with the same NZHEC code can fall under different expenditure modules. For example, some vehicle purchases were classified under the recreation module, though the vast majority were classified under the transport module. In these cases, we rely on the module classification (e.g., transport or recreation) to classify these products.

From the literature, there did not seem to be a standard methodology for classifying transport-related expenditures. Most of the classifications we found classified expenditures separately for private vehicles and public transport as well as classifying expenditures related to private vehicles into ownership costs (purchase or lease, insurance, licensing, registration, financing) and operating costs (fuel and oil, maintenance, tyres). We follow a categorisation developed by Statistics New Zealand for a recently developed transportation cost index which allows us to follow the general classifications seen in the literature (Statistics New Zealand, 2018). The full classification is provided in Appendix A2.

We then aggregate the individual expenditures to the household level for each of the transport categories as well as for the main HES components (housing, food, clothing, health, utilities, education). We separate recreational vehicle expenditures from other recreational expenditures and transport-related travel expenses from other travel expenses. To these aggregated expenditures, we append additional information about the household (e.g., total income, household size, number of adults, number working, number retired, material wellbeing, dwelling size).

[18] The survey asks about vehicles sold, and these are recorded as negative expenditures.

We also use © OpenStreetMap[19] to calculate the car travelling distance (in minutes and in kilometres) between each household and the nearest territorial authority (TA) seat and to the household's own TA seat using the centroid of the household's meshblock and the centroid of the seat[20] which is the commercial and political hub of the area. Since the Auckland TA covers a large geographic area and population, we disaggregate it into 13 wards. There are currently 67 TAs, so there are 79 territorial authorities or Auckland wards, which we will hereafter refer to as the TAW.[21] For the vast majority of households, the closest TAW is the one in which they live. We also calculate the distance to the nearest city[22] from the centroid of the household's meshblock. Appendix A2 provides more details on these calculations.

For the price of petrol, we use retail prices available through the Ministry of Business, Innovation and Employment (MBIE).[23] These data provide retail price information for regular and premium petrol as well as for diesel. For our analysis, we primarily use the quarterly nominal price of petrol which is a sales-weighted average of the regular and premium petrol prices for all of New Zealand. Based on the interview month, we match the quarterly prices to the household expenditure data.

Figure 2 shows the average retail fuel prices during each survey period. Each price series follows similar trends but with diesel prices substantially lower than petrol prices.[24] Moreover, prices in 2012/13 and 2018/19 are in fairly similar ranges with a mean average petrol price of \$2.33 and \$2.22 per litre respectively (as shown in Table 1), and prices in the other years being fairly similar to each other with the exception of diesel in 2015/16 (mean of \$1.13 per litre) which is substantially lower than diesel prices in 2006/07 and 2009/10 (mean of \$1.34 and \$1.29 per litre).

[19] We use the *osrmtime* programme developed for Stata by Huber and Rust (2016). This programme uses Open Source Routing Machine (OSRM) to find the optimal route by car, by bicycle, or on foot based on OpenStreetMap data. OpenStreetMap® is open data, licensed under the Open Data Commons Open Database License by the OpenStreetMap Foundation. See https://www.openstreetmap.org/copyright for more information.

[20] We define the seat of the TA as the Area Unit in that TA containing the meshblock with the highest population density based on data from the 2013 Census of Population and Dwellings. For example, the seat of Wellington City TA is the Lambton Area Unit.

[21] To our knowledge, this classification was first used in Hyslop et al. (2019).

[22] Cities include 6 metropolitan areas (Auckland, Hamilton, Tauranga, Wellington, Christchurch, Dunedin) and 11 large regional centres (Whangarei, Rotorua, Gisborne, Hastings, Napier, New Plymouth, Whanganui, Palmerston North, Kapiti Coast, Nelson, Invercargill), as defined by Statistics New Zealand's list of Functional Urban Area 2018 V1.0.0.22.

[23] For more information, see https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/energy-prices/.

[24] With petrol, excise taxes are paid at the pump, but with diesel, the road-user costs are paid separately. Therefore, the price of 'diesel' does not capture the full cost.

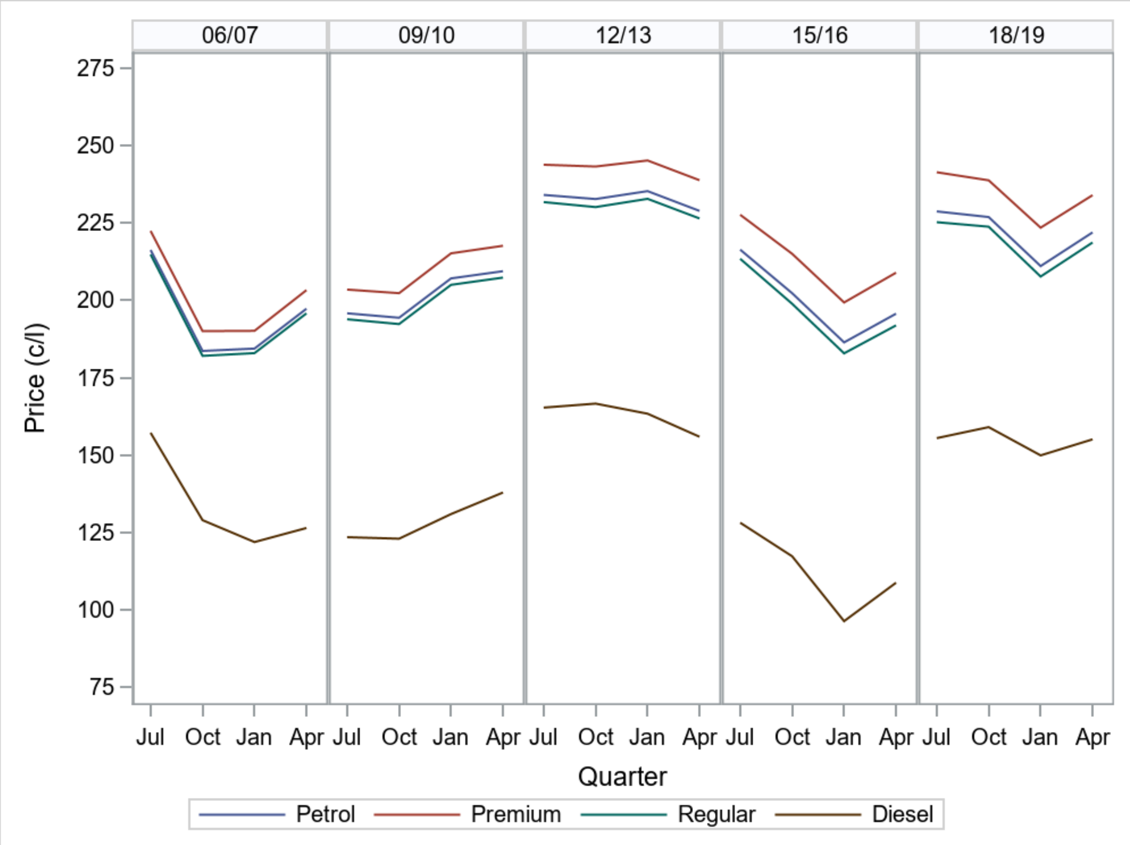


Figure 2: Quarterly Fuel Prices During the HES Expenditure Survey Periods (July-June)

Table 1: Nominal Fuel Prices (c/l) during the HES Survey Period

Survey Year	Petrol		Premium		Regular		Diesel	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
06/07	195.38	15.26	201.46	15.29	193.88	15.29	133.59	15.99
09/10	201.65	7.68	209.63	7.88	199.62	7.64	128.79	7.07
12/13	232.73	2.77	242.76	2.76	230.27	2.78	162.79	4.79
15/16	200.18	12.61	212.72	11.87	196.76	12.90	112.60	13.46
18/19	222.15	7.94	234.40	7.91	218.84	7.96	154.84	3.76

Source: Ministry of Business, Innovation and Employment. Quarterly prices are depicted in Appendix 3.

3.2 Analytical approach

The main categories for transport expenditures are as follows:

- Vehicle purchasing costs
- Fuels and lubricants
- Registration, WOF, RUC, parking, licence fees, etc.
- Vehicle parts and maintenance
- Vehicle insurance

- Vehicle interest
- Public transport
- Cycling
- Other transport

In HES, expenditures can be negative, and these negative expenditures generally represent refunds, reimbursements, or sales. For example, negative expenditures with an NZHEC code for a vehicle generally represents a vehicle that was sold or traded in. In most cases, these negative amounts are small, except for large capital items like vehicles. To keep track of these negative and positive amounts, our transport expenditure categories were measured using two variables: one variable for expenditures greater than or equal to zero and one variable for expenditures less than. In general, we focus on positive expenditures particularly when analysing individual transport categories. There are a small number of households in the data with total household expenditures less than zero (generally due to one large negative expenditure). Following Flues and Thomas (2015), we drop these households from the analysis.

We begin with a basic descriptive analysis of the different types of transport expenditures to examine trends over time and across different groups. Survey weights for the expenditure sample are used to more accurately reflect the population. For our measures of household income, we use both annual gross income and annual total expenditure, but primarily focus on total expenditure. We divide the sample into quintiles for each survey year for both income measures to examine differences between the results. Since retirees tend to have different transport needs than other household types, we also examine transport expenditures for households with at least one retiree.[25]

Table 2 provides summary statistics for the full HES sample, each expenditure quintile, and households with positive public transport. The full HES sample has similar rates of homeownership (67%) to those reported in the censuses during this period (65-67%) (Statistics New Zealand, 2020c). Moreover, the proportions of different household types in our full sample appear consistent with those reported in the censuses during the same time period (Statistics New Zealand, 2020c). As shown in Table 2, about 21% of HES households in the full sample have at least one retiree, though this percentage is more than double for households in the lowest expenditure quintile (48%). Only 7% of households in the highest quintile have at least one retiree. In the full sample, 75% of households are located on the North Island with 31% in the Auckland region and 11% in the Wellington region.

[25] We originally used a categorical which also distinguished households with at least one but not all adults were retired from those where all adults were retired; however, for a number of analyses, we started to have very small sample sizes in these categories with large variances. Hence, we decided to use the binary variable instead.

Table 2: Summary Statistics for the Full Sample, the Any PTX Sample, and Expenditure Quintiles 1-5

Variable	(1) Full Sample	(2) Any PTX	(3) Quintile 1	(4) Quintile 2	(5) Quintile 3	(6) Quintile 4	(7) Quintile 5
Public Rental	0.072	0.097	0.169	0.088	0.052	0.040	0.013
Private Rental	0.240	0.304	0.175	0.338	0.298	0.231	0.157
Homeowner	0.666	0.586	0.614	0.550	0.633	0.712	0.823
Maori HH Member	0.176	0.174	0.184	0.212	0.180	0.177	0.126
One person HH	0.209	0.112	0.583	0.260	0.123	0.058	0.023
One couple HH	0.265	0.146	0.195	0.294	0.304	0.299	0.234
Coupled parent HH	0.310	0.404	0.066	0.188	0.343	0.424	0.525
Sole Parent HH	0.085	0.108	0.105	0.152	0.086	0.047	0.032
Other 1-family HH	0.059	0.100	0.022	0.049	0.073	0.072	0.078
All other HH	0.073	0.128	0.028	0.056	0.071	0.100	0.108
Retirees in HH	0.214	0.099	0.481	0.266	0.147	0.103	0.072
Auckland	0.309	0.440	0.217	0.280	0.302	0.335	0.410
Canterbury	0.134	0.120	0.133	0.141	0.133	0.134	0.127
Rest of NI	0.330	0.142	0.406	0.369	0.340	0.307	0.226
Rest of SI	0.116	0.057	0.134	0.122	0.126	0.109	0.087
Wellington	0.112	0.241	0.110	0.087	0.099	0.114	0.149
Housing Costs	13,125	16,393	4,895	9,322	12,456	15,697	23,262
	13,287	*14,082*	*4,121*	*7,089*	*9,294*	*11,700*	*20,016*
Distance (in mins)							
TAW	11.3	8.5	12.0	11.8	11.1	11.0	10.4
	12.9	*8.5*	*15.1*	*14.4*	*12.5*	*11.5*	*10.1*
City	25.1	16.1	30.3	27.2	24.5	23.1	20.3
	29.2	*18.2*	*34.4*	*31.6*	*28.9*	*26.0*	*22.8*
Fuel & Lube							
HH has exp (0/1)	0.717	0.747	0.454	0.699	0.775	0.816	0.842
Exp Amount ($)	2,456	2,764	804	1,689	2,456	3,204	4,131
	2,769	*2,894*	*1,232*	*1,758*	*2,279*	*2,863*	*3,698*
Share of Total Exp	0.045	0.038	0.044	0.050	0.049	0.045	0.036
	0.051	*0.039*	*0.077*	*0.051*	*0.045*	*0.039*	*0.032*
Public Transport							
HH has exp (0/1)	0.130	1.000	0.059	0.089	0.128	0.151	0.220
Exp Amount ($)	180	1387	42	98	139	218	401
	911	*2,174*	*251*	*565*	*647*	*849*	*1,597*
Share of Total Exp	0.003	0.022	0.002	0.003	0.003	0.003	0.003
	0.013	*0.031*	*0.014*	*0.016*	*0.012*	*0.011*	*0.013*
N (weighted obs)	8,244,000						

Notes: For binary variables, only the means are presented; however, for continuous variables, the means and standard deviations are provided, with the standard deviations in italics below the mean and means including households with zero values.

To examine the factors that affect household transport expenditures, we use regression analysis. First, we use logit analysis to explore the household characteristics which affect the likelihood that households will have positive or negative expenditures in a given category. The main estimation equation for the logit is as follows:

$$\Pr(y_i \neq 0 \mid x_i) = \frac{\exp(\boldsymbol{x_i}\boldsymbol{\beta})}{1 + \exp(\boldsymbol{x_i}\boldsymbol{\beta})} \quad (1)$$

where $y_i = 1$ when household *i* has non-zero expenditures and $\boldsymbol{x_i}$ is a vector of characteristics of household *i* which include the variables delineated below.

We then use generalised linear models to understand the degree to which these different characteristics affect the amount (or share) of the expenditures. In the linear model, we use three dependent variables that include the following: the amount of expenditure spent by the household in the expenditure category ($), the logged value of the household's expenditure in the expenditure category (LN), and the share of the household's total expenditure that is allocated to the expenditure category (SH). We use the value of expenditure in both log and linear terms since the linear value allows us to take into account all households in the sample (including those with zero values), whereas using the log value provides estimates conditional on households having a non-zero value for the expenditure. Hence, the results provided using logged expenditures are conditional on the household having expenditures in the category. We estimate the following general equation for an outcome of interest (Y_i) for household *i*:

$$Y_i = \beta_0 + \sum_{k=2}^{5} \beta_{\mathrm{k}} Q_{ki} + \boldsymbol{X_i'}\boldsymbol{\gamma} + \epsilon_i \quad (2)$$

where Q_{ki} is an indicator for whether household *i* is in quintile *k* (either based on total expenditure or income), and $\boldsymbol{X_i'}$ is a vector of control variables.

In both the linear and logistic regression models, we use robust standard errors and probability weights; however, the number of observations shown in the results is the number of unweighted observations. We also drop observations with total household expenditures less than zero.[26]

The explanatory variables used for the main analysis are based on the following measures:

- *HES year*: binary variables which allow us to control for time effects across survey years;[27]
- *Interview month*: binary variables which allow us to control for seasonal effects in transport over the year;

[26] There are a handful of observations in each year with total household expenditures less than zero. These appear to be households that had a large capital sale in the year (e.g., house sale or vehicle sale).
[27] All analyses are done using nominal dollars.

- *Average quarterly petrol price*: retail prices (in nominal terms) available through MBIE using the petrol price which is a sales-weighted average of the regular and premium petrol prices;
- *Household composition:* different measures of household composition
  - *Household size* is a continuous measure of the number of individuals;
  - *Household type* is a categorical variable including one-person, one couple (no children), coupled parents, sole parents, other one-family households, all other households;
  - *Retired* is a binary variable to distinguish households with at least one retiree;
  - *Children* is a binary variable to distinguish households with dependent children;
  - *Education level* is a measure of the highest education level of a household member (No qualification; Secondary school; Post-secondary; Bachelor; Post-graduate);
- *Housing tenure*: binary variables which allow us to distinguish public rentals,[28] private rentals, and owner-occupied dwellings;
- *Region*: binary variables which allow us to control for different transport options and prices in different regions (Auckland, Wellington, rest of the North Island, Canterbury, and rest of the South Island);
- *Distance*: measures household's distance from economic centres as described in Appendix A2;
- *Household income*: measure of household income either as total gross income or total expenditures, split into weighted quartiles and quintiles;[29]
- *Household housing costs:* continuous measure of the household's total housing costs, which consists of expenditures from mortgage principal repayments, mortgage interest payments, mortgage application fees, rent payments,[30] other payments associated with renting (e.g., bonds paid in the last 12 months), property rates payments (both regional and local government), and payments associated with building-related insurance;[31]

[28] Respondents are asked if the dwelling is rented, and if yes, who owns the dwelling. Potential responses include the following: private person; private trust; local authority or city council; Housing New Zealand; other state-owned corporation, state-owned enterprise, or government department; or business or other organisation. For the main analyses, the dwelling was considered a public rental if the landlord was not a private person or private trust. In robustness checks, we also used different combinations of the public landlord types.
[29] The lowest income households are in the first quartile or quintile. We refer to the expenditure quintiles as EQ1-EQ5 and the income quintiles as IQ1-IQ5.
[30] Actual rents are rent payments paid by the household are included. Imputed rent is the estimated benefit value from home ownership of not having to pay rent. Imputed rent is not included in actual rents (Statistics New Zealand, 2020b).
[31] See Statistics New Zealand (2020b) for more information about the concepts related to housing costs.

4 Results

We begin the discussion of results with our descriptive analysis by examining the different categories of transport expenditures for different types of households in section 4.1 and then examine the trends in these expenditures over time in section 4.2. We discuss the results of the regressions analyses in sections 4.3 and 4.4. In section 4.3, the results from the logistic regressions are presented, and these describe the factors that influence the likelihood that households have certain types of transport expenditures (i.e., fuel, public transport, vehicle purchases and vehicle sales). Section 4.4 contains the results from the linear regressions that describe the factors that influence the amount of households' transport expenditures as well as the share of a household's total expenditure spent on certain transport items (i.e., fuel and public transport). We focus on these expenditures for our dependent variables in the regression analyses because these are the most likely to be directly affected by fuel prices and are closest to the typical analyses conducted in the distributional impacts literature.

4.1 Descriptive Analysis: Composition of Household Transport Expenditures

In Figure 3, we show the average share of household transport expenditures spent within each transport category by different income groups (using expenditure quintiles) and by the full sample. In the full sample, the largest share of transport expenditures was spent on vehicle purchases (37%), the second largest share was spent on fuel (33%), and the third largest share was spent on vehicle maintenance (10%). Moreover, another 15% of households' transport expenditures in the full sample was spent on other vehicle operating costs – 8% for registration and fees and 7% for interest and insurance payments. Hence, the average household in the full sample allocated 95% of their transport expenditures to vehicle-related costs. In contrast, a little more than 2% of households' transport expenditures were spent on public transport, and less than 1% (about 0.6%) were spent on cycling.

Compared to the full sample, the expenditure patterns across the quintiles were very different. The lowest three expenditure quintiles (EQ1-EQ3) spent a larger share of their transport expenditures on fuel than on vehicles, with the lowest expenditure quintile (EQ1) spending 44% of their transport expenditures on fuel and only 14% on vehicle purchases. Households in EQ1 spent about 26% of their total transport expenditures on other vehicle operating costs – 15% for registration and fees and 11% for vehicle insurance and interest. For this quintile, maintenance expenditures were 12% of total transport expenditures. So, despite the differences in the allocation shares compared to the full sample, the average household in EQ1 still allocated a similar share of its total transport expenditures (96%) to vehicle-related expenditures. In addition, the share allocated to public transport expenditures for the average EQ1 household (2.4%) is similar to the share allocated by the full sample (2.3%). Expenditures for cycling in this group, however, are about one-third the share allocated by the full sample (0.2% and 0.6% respectively).

While the breakdown of transport expenditures is fairly similar for EQ1 to EQ3, the fourth quintile looks most similar to the full sample as shown in Figure 3. The breakdown of transport expenditures for households in EQ5 appears to be different from both the full sample and from the lower four quintiles. For example, the largest share of expenditures for households in EQ5, almost 50%, were allocated to vehicle purchases while only about 25% were allocated to fuel. The share of transport expenditures allocated to vehicle maintenance for households in EQ5 (9.2%) were similar to those in EQ4 (9.5%). In fact, the share of transport expenditures allocated to maintenance is similar across all the groups, ranging from 9.2% (EQ5) to 11.8% (EQ1).

Overall, these patterns suggest that lower-income households spent the largest share of their transport expenditures on fuel and that the average share declines over each subsequent quintile. Households in EQ1 allocated 44% of their transport expenditures to fuel while households in EQ5 allocated 26%. The opposite is true for vehicle purchases – households in EQ5 allocated approximately 47% of their annual transport expenditures to vehicle purchases, whereas households in EQ1 allocated only 14%, and this percentage decreases for each quintile from EQ5 to EQ1. Regardless of quintile, approximately 95% of household transport expenditures were vehicle-related.

4.2 Descriptive Analysis: Trends in Household Transport Expenditures

There are several key findings from analysing the household transport expenditures in this section:

- Between 2006/07 and 2015/16, the percentage of households reporting fuel expenditures was between 70 and 80%, whereas the percentage of households reporting public transport expenditures was between 13 and 15% over the same time period.
- The proportion of households (for all household quintiles) reporting fuel expenditures dropped substantially in 2018/19 compared to earlier survey years. We see a similar drop in reporting of public transport expenditures in 2018/19, but it does not look as substantial as the drop for fuel expenditures. While there are several potential reasons, it was not possible to disentangle them. We do not believe this affects the overall findings of this study because the relative patterns within and across groups still appear to hold true. Moreover, we also generally either disaggregate the results across years or add time controls, yet even when pooling results across years, 2018/19 only contributes one-fifth of the observations.

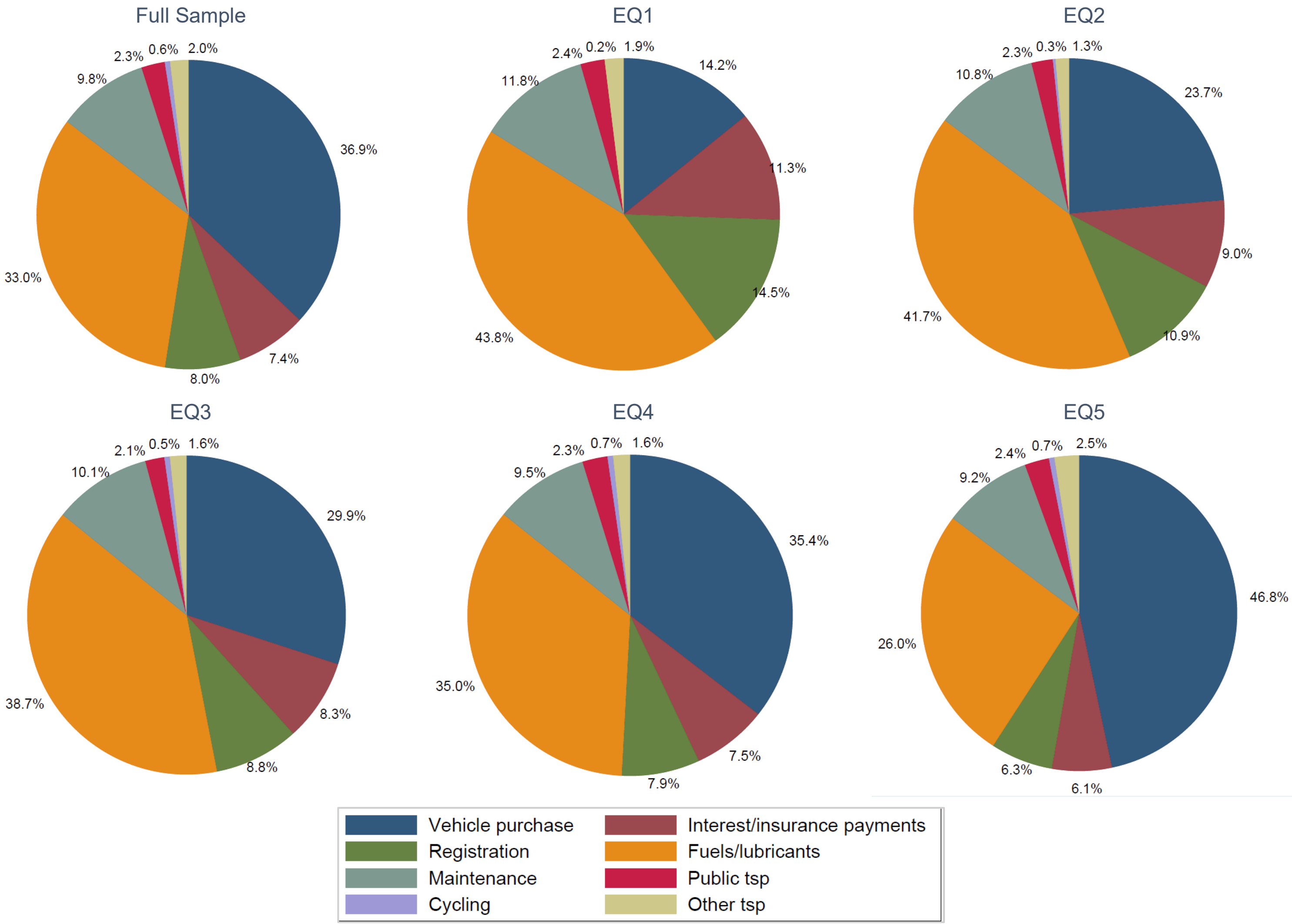


Figure 3: Share of Household Annual Transport Expenditures by Transport Expenditure Category and Expenditure Quintile

- The proportion of households in the lowest quintile (EQ1) reporting fuel expenditures was substantially lower – 20 to 30 percentage points lower – than the proportions in the other quintiles.
- The proportion of households reporting public transport expenditures was also lowest in the lowest quintile (6% of EQ1) and highest in the highest quintile (22% of EQ5).
- The average household with fuel expenditures spent significantly more on fuel in 2018/19 than in earlier years.
- Households in rural areas were more likely to report fuel expenditures than households in urban areas. This was also generally true for reporting petrol-only or diesel-only expenditures.
- In the full sample, 5-10% of households reported only diesel in the fuel expenditure category. Households in the lower quintiles had lower rates of reporting diesel as their only transport fuel (2-5% for EQ1), whereas households in the higher quintiles had higher reporting rates (8-12% for EQ5).
- Households with at least one retired person are less likely to report fuel expenditures and less likely to report public transport expenditures. This either means these households require different means to meet their transport needs or they do less travel.
- When examining transport expenditures in terms of their share of the household's total budget, households generally allocate similar shares of their total budget regardless of their expenditure quintile. There are only a few exceptions.
- Households in the highest quintile (EQ5) allocated a significantly smaller share of their total household expenditure to fuel and to total vehicle operating costs than households in the other quintiles.
- Households in the lowest quintile (EQ1) allocated the largest share of their total expenditures to insurance, whereas households in the highest quintile (EQ5) allocated the smallest share to insurance.
- Maintenance expenditures decreased in nominal terms between 2006/07 and 2018/19. Moreover, these expenditures also declined significantly as a share of total household expenditure for all quintiles over this time period, and by 2018/19, households were allocating the same share of their expenditures to maintenance regardless of quintile.
- When including all households in the calculation of average expenditure share allocated to vehicle purchases, the lowest quintile (EQ1) had the lowest share allocated to vehicle purchases, and the highest quintile (EQ5) had the highest share. However, when only including households with vehicle purchases, households in each quintile allocated a similar proportion of their budget to vehicle purchases, particularly

in the later years of the survey. In 2018/19, the average share was about 18% of total expenditures for all households regardless of quintile.

These findings are briefly discussed in the section below along with the supporting evidence (graphs and tables).

4.2.1 Fuel

Starting with fuel expenditures, the percentage of households reporting fuel expenditures remained fairly steady between 2006/07 and 2012/13 (close to 80%), with a slight drop in 2015/16 (73%), but with a substantial drop in 2018/19 (57%) as shown in panel *a* of Figure 4 and column 1 of Table 3. Given the changes to the survey in 2018/19, it is difficult to know if the change is due to an actual behaviour change. This drop could be due to a change in the sample, due to the change in the diary timeframe (7 days compared to 14 in previous years), an actual behaviour change, or some combination of all three.[32] However, it is difficult to disentangle these different effects.

From Table 3, we can see that the proportion of households reporting fuel expenditures varies by quintile, with the lowest quintile having the lowest share of households reporting fuel expenditures (around 50% in each year between 2006/07and 2015/16 which is between 20 and 30 percentage points lower than the next highest quintile over this time period).

As with the full sample, we see the proportion of EQ1 households reporting fuel expenditures in 2018/19 drop markedly with only 30% of households reporting fuel expenditures. However, we also see a slight decline in this proportion for each quintile in 2015/16 – households in the lowest quintile dropped from 55% to 47% while households in the highest quintile dropped from 95% to 84%.

The average nominal annual fuel expenditure across all households, including those with no fuel expenditure,[33] is between \$2,000 and \$3,000 during our analysis time period (also shown in panel a of Figure 4 and column 1 of Table 3). Moreover, households in 2012/13 and 2018/19 have very similar mean expenditures despite the drop in households reporting fuel expenditures in 2018/19 (approximately \$2,500). This suggests that the average household with fuel expenditures spent substantially more on fuel in 2018/19 than in 2012/13, from \$2,800 to \$4,900. However, given the change in diary reporting from 14 days to 7 days in

[32] Given that expenditures in other categories collected during the survey as opposed to the diary (e.g., registration, maintenance) do not show the same drop in the percentage of households reporting them, it may be due to changes in the diary time period. Moreover, households reporting public transport expenditures also dropped in 2018/19 which are collected using the diary.
[33] From the literature, including households with no fuel expenditures is important for determining the regressive or progressive nature of a tax.

2018/19, it is likely that the sample of households with fuel expenditures captured in 2018/19 use more fuel than the samples captured in previous years.

As shown in panel b of Figure 4, households with no retirees, on average, look similar to those in the full sample. Households with at least one retired person, however, are less likely to report fuel expenditures (around 60% for those with retirees compared to around 80% for those without) and to have much lower average expenditures (around $1,000 for retiree households compared to $2500 for non-retiree households in 2006/07), though with more of an upward trend than households without a retiree.

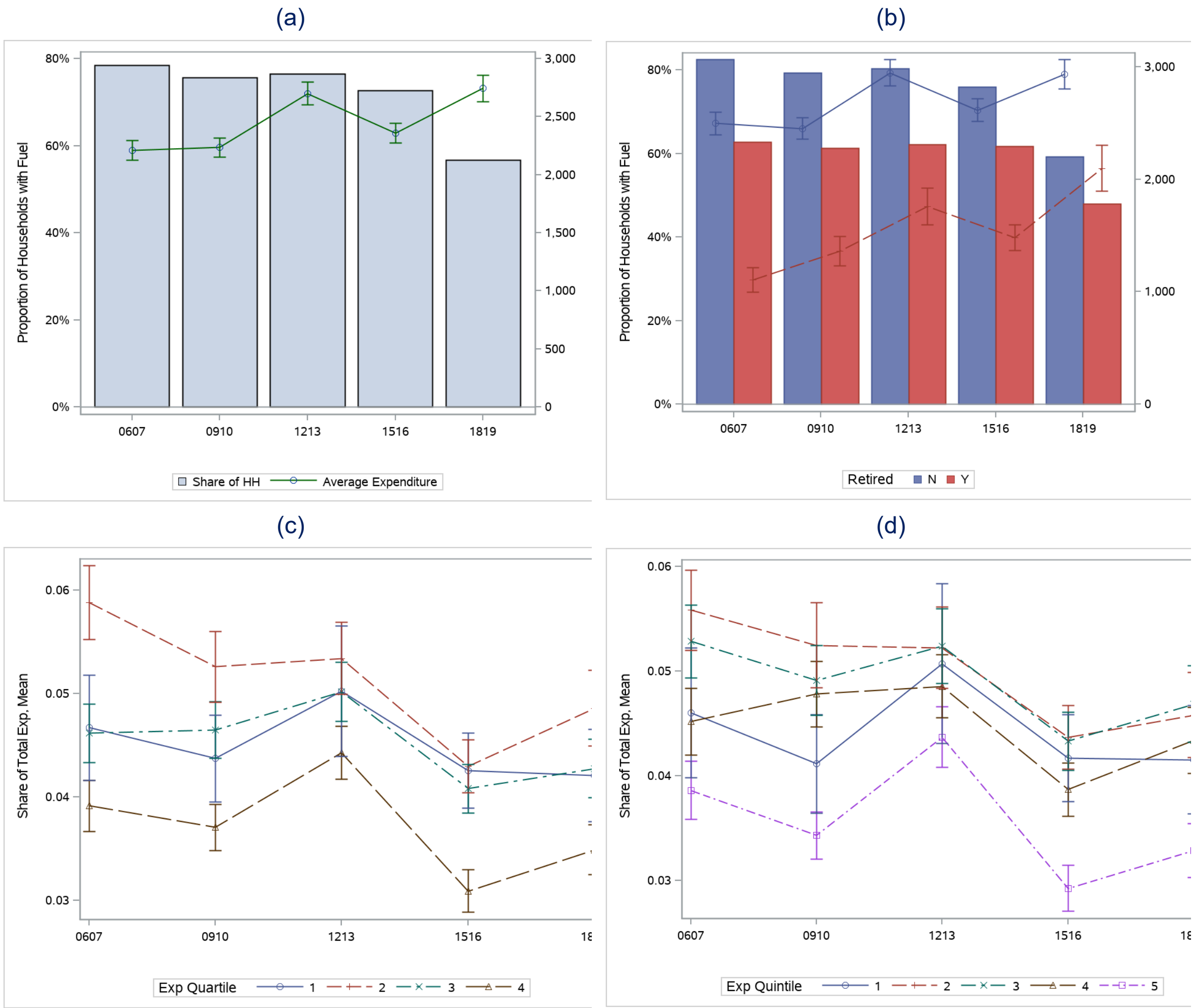


Figure 4: Household Expenditures for Fuel

Table 3: Fuel expenditure by quintile

		Share of households reporting				Mean expenditure		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Survey Year	Quintile	Any fuel	Petrol only	Diesel only	Petrol or diesel only	Petrol only	Diesel only	Other fuel or lube
2006/07	1	0.500	0.478	0.031	0.498	607.8	37.5	6.9
	2	0.803	0.775	0.059	0.797	1,466.4	90.9	28.2
	3	0.840	0.811	0.074	0.834	2,054.5	131.1	41.4
	4	0.880	0.847	0.131	0.876	2,390.4	298.8	39.6
	5	0.897	0.868	0.104	0.892	3,561.3	238.6	53.1
	Overall	0.784	0.756	0.080	0.779	2,015.4	159.3	33.8
2009/10	1	0.548	0.531	0.036	0.543	730.4	41.9	15.6
	2	0.788	0.747	0.086	0.788	1,564.4	108.3	33.7
	3	0.851	0.842	0.084	0.851	2,148.5	143.8	45.2
	4	0.900	0.872	0.131	0.899	2,889.6	234.0	27.6
	5	0.910	0.902	0.124	0.909	3,323.4	213.0	72.4
	Overall	0.799	0.779	0.092	0.798	2,130.7	148.2	38.9
2012/13	1	0.546	0.509	0.046	0.541	841.1	80.0	17.4
	2	0.768	0.741	0.043	0.760	1,706.2	75.2	54.4
	3	0.855	0.837	0.069	0.853	2,482.3	136.3	63.3
	4	0.905	0.876	0.110	0.902	3,231.0	232.0	69.6
	5	0.950	0.930	0.123	0.945	4,467.8	322.3	106.2
	Overall	0.805	0.779	0.078	0.800	2,545.2	169.1	62.2
2015/16	1	0.468	0.442	0.027	0.464	789.0	56.4	12.0
	2	0.706	0.684	0.046	0.702	1,532.4	65.0	46.9
	3	0.804	0.784	0.064	0.803	2,265.5	102.3	54.1
	4	0.812	0.785	0.071	0.810	2,877.9	141.6	36.9
	5	0.842	0.810	0.079	0.834	3,557.8	153.1	94.0
	Overall	0.726	0.701	0.057	0.722	2,203.2	103.7	48.7
2018/19	1	0.316	0.301	0.021	0.315	795.2	52.1	10.3
	2	0.512	0.491	0.026	0.502	1,661.7	77.7	31.9
	3	0.616	0.580	0.051	0.611	2,454.8	151.4	81.3
	4	0.690	0.660	0.066	0.687	3,412.9	255.7	40.6
	5	0.693	0.653	0.078	0.689	4,321.7	309.7	57.5
	Overall	0.565	0.537	0.049	0.561	2,528.4	169.3	44.3

Notes: Expenditures are in nominal prices. Households that do not report a particular type of expenditure are treated as having zero expenditure for that category.

Table 4: Fuel expenditure by urbanisation

		Share of households reporting				Mean expenditure		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Survey Year	Urban sector	Any fuel	Petrol only	Diesel only	Petrol or diesel only	Petrol only	Diesel only	Other fuel or lube
2006/07	Major urb	0.799	0.777	0.053	0.794	2,047.0	95.9	27.7
	Other urb	0.760	0.732	0.075	0.754	1,747.9	143.1	28.1
	Rural	0.817	0.779	0.163	0.814	2,623.2	360.9	69.4
	Overall	0.784	0.756	0.080	0.779	2,015.4	159.3	33.8
2009/10	Major urb	0.786	0.773	0.050	0.785	2,097.4	78.5	32.9
	Other urb	0.792	0.767	0.102	0.790	1,882.7	167.0	37.8
	Rural	0.873	0.844	0.203	0.873	2,854.0	320.9	54.6
	Overall	0.799	0.779	0.092	0.798	2,130.7	148.1	38.9
2012/13	Major urb	0.830	0.815	0.051	0.826	2,748.4	121.3	60.6
	Other urb	0.775	0.743	0.069	0.766	2,184.5	139.1	62.5
	Rural	0.797	0.748	0.204	0.797	2,730.1	438.4	70.1
	Overall	0.805	0.779	0.078	0.800	2,545.2	169.1	62.2
2015/16	Major urb	0.733	0.720	0.036	0.732	2,262.0	61.9	46.6
	Other urb	0.710	0.679	0.054	0.703	1,944.1	88.9	44.0
	Rural	0.742	0.685	0.141	0.737	2,591.8	295.9	62.2
	Overall	0.726	0.701	0.057	0.722	2,203.2	103.6	48.7
2018/19	Major urb	0.535	0.515	0.029	0.531	2,467.7	112.3	31.1
	Other urb	0.568	0.537	0.048	0.562	2,311.9	152.3	68.5
	Rural	0.652	0.602	0.108	0.647	3,183.3	378.7	31.9
	Overall	0.565	0.537	0.049	0.561	2,528.4	169.3	44.3

Notes: Expenditures are in nominal prices. Households that do not report a particular type of expenditure are treated as having zero expenditure for that category.

Figure 4 includes graphs of the share of total expenditures households spent on fuel[34] by expenditure quartile (panel c) and by expenditure quintile (panel d) in each survey year.[35] In both panels, there is a fair amount of overlap in the confidence intervals around the mean shares for all the groups, but with the highest group being the most distinct. In 2012/13, both panels show a tight clustering of all the groups, whereas in 2015/16, there is a tight clustering for all but the highest income group (around 0.03). So, households in the highest quintile

[34] For this analysis, we exclude households with total expenditures less than zero and households with fuel expenditure shares greater than 10.
[35] We include both to compare and contrast the differences between using quartiles and quintiles.

allocate the lowest share of their transport budget as well as the lowest share of their total budget to fuel.

We further analyse spending on fuels by analysing petrol and diesel separately first by quintiles (Table 3) and then by urbanisation level (Table 4). The proportion of households reporting only petrol in the fuels category is very similar to the proportion of households reporting any fuel expenditures. The percentage of households in the full sample reporting only diesel expenditures, however, ranges from 5 to 9% depending on the survey. The lowest quintile generally had the lowest percentage of households reporting only diesel expenditures – ranging from 2% (2018/19) to 5% in (2012/13). In the first two survey years, households in quintile 4 had the highest percentage of households reporting diesel only (13% in both years), but in the last 3 survey years, quintile 5 had the highest percentage (12%, 8%, and 8% respectively).

The average expenditures in Table 3 include households with zero expenditures. Hence, the annual average household expenditure on diesel is much lower than that for petrol given the much lower proportion of households with diesel expenditures. When estimating the average for households with diesel expenditures, the numbers are much more on par, particularly for households in the lowest quintile. For example, in 2006/07, the average for households in the lowest quintile with these expenditures was approximately $1,300 for petrol and $1,200 for diesel. For the highest quintile in 2006/07, the average annual fuel expenditure for petrol-only households with these expenditures was approximately $4,100 compared to $2,300 for diesel-only households.[36]

Looking at the urban-rural split, the proportion of households reporting petrol-only fuel expenditures are very similar to the proportion of households reporting any fuel expenditures. The proportion of diesel-only households is much lower than the proportion reporting petrol-only. About 5% of households in major urban areas reported only diesel expenditures in the first three survey years, whereas 16-20% of households in rural areas reported only diesel expenditures during the same time frame. The percentage of households in other urban areas with diesel-only expenditures is generally in between the percentages for major urban and rural areas, with 7-10% of households in other urban areas reporting diesel-only expenditures in the first three survey years.

In terms of spending, the average annual expenditure for petrol tended to be slightly higher for rural households than for households in urban or other urban areas in most survey years. In 2015/16, the average annual expenditure for petrol by rural households was $2,600,

[36] With petrol, excise taxes are paid at the pump, but with diesel, the road-user costs are paid separately. Therefore, the price of diesel does not capture the full cost.

whereas it was $2,300 for households in major urban areas. Conditional on having petrol expenditures, however, the difference could be much greater. In 2015/16, the average rural household with petrol-only expenditures reported annual expenditures for petrol of $3800 and the average urban household reported $3100. Moreover, the average household with petrol-only expenditures tended to spend more on fuel than the average household with diesel-only expenditures, even conditional on having these expenditures. In 2018/19, the average annual fuel expenditure for rural, petrol-only households with these expenditures was approximately $5,300 compared to $3,500 for diesel-only, rural households.[37] For households in major urban areas in 2018/19, the comparable numbers were $4,800 for petrol-only households and $3,900 for diesel-only households.

For diesel, the average annual expenditure is generally much larger for rural households compared to households in urban areas (ranging from $300 to $450 for rural households compared to a range of $60 to $120 for households in major urban areas); however, this is primarily driven by the higher rate of diesel-only households in rural areas. Conditional on reporting only diesel fuel expenditures, the average annual expenditure for households in rural and major urban areas was similar in most survey years, with rural households' expenditures exceeding those for households in major urban areas in some years and the opposite being true in other years. For example, in 2012/13, the average household reporting positive, diesel-only expenditures in major urban areas spent $2,400 for diesel compared to households in rural areas which spent $2,150. In 2015/16, however, the same average for households in rural areas was reported as $1,700 compared to $2,100 for rural households.

4.2.2 Private Vehicle Costs

For the other components of private vehicle costs, we see different trends. Around 50% of households reported maintenance costs, with this remaining fairly steady across all the survey years as shown in panel a of Figure 5. Still, average annual maintenance costs in nominal terms declined between 2006/07 and 2018/19 from approximately $800 annually to $600, and as a share of total expenditure, maintenance costs also declined for all income quintiles over this time period (shown panel d of Figure 5). In addition, there is almost complete overlap in the confidence intervals surrounding each quintile mean in panel d, which indicates that there is no distinguishable difference in average expenditure shares across income groups and that all income groups allocated a similar share of their budget to vehicle maintenance.

For registration and licensing costs, the share of households reporting expenditures in this category is fairly stable across the four years (approximately 80%) as shown in panel b of Figure 5. In terms of expenditures, annual expenditures in nominal terms were fairly similar in

[37] As stated in footnote 36, the price of diesel does not capture the full cost, and diesel expenditures will be lower.

2006/07 and 2018/19 (between $400 and $500) but peaked around $700 in 2012/13. As a share of total expenditures, registration and licensing costs declined slightly between 2006/07 and 2018/19 for all quintiles as shown in panel e of Figure 5, but with an increase in the mean share for all groups in 2012/13. The mean share of these costs is highest for households in the lowest expenditure quintile and lowest for the highest expenditure quintile; however, in the latter survey years, the confidence intervals for all quintiles are generally overlapping, especially in 2015/16. In 2018/19, the confidence interval for the lowest quintile is distinct from the other groups, indicating that EQ1 households allocated a significantly larger share of their budget to these types of costs compared to households in other quintiles. In the early years of the survey, the confidence interval for the lowest two quintiles overlapped with each other but were distinct from the those for the other three quintiles.

The share of households reporting private vehicle insurance expenditures remained steady (around 60%) across all survey years (panel *c* of Figure 5), but average annual expenditures across the sample increased over the time period analysed, with a low of just over $400 in 2009/10 to just over $500 in 2018/19. The mean expenditure share for each quintile, however, remained fairly steady from 2009/10 to 2018/19 (panel *f* of Figure 5). As with registration and licensing costs, the lowest quintile has the highest share, and the highest quintile generally has the lowest share (with the exception of 2006/07). Moreover, by 2018/19, the average share for the lowest and highest quintiles are significantly different from each other and from the shares for the middle three quintiles.[38]

When we add the aforementioned expenditures together to get an estimate of private vehicle operating costs, we see a slight upward trend from 2006/07 to 2018/19 as shown in panel a of Figure 6; however, average costs in 2012/13 are very similar to those in 2018/19. As a share of total expenditures, there has been a general decline for each quintile over the entire time period (shown in panel *b* of Figure 6). Overall, there is a fair amount of overlap in the confidence intervals around the means for each quintile. However, the highest expenditure quintile has the lowest mean share in each survey year, and this share is significantly different from the shares for the other groups in three survey years: 2009/10, 2015/16, and 2018/19.

We also examine average expenditures for vehicle purchases, both for all households and for only those households with reported vehicle purchases. In both cases, the average expenditure across all households increased over the full time period (shown in panels *a* and *b* of Figure 7), but as shown in panel *a*, the average share of households with these

[38] When using quartiles, each quartile in 2018/19 has a significantly different share (results not shown).

expenditures also increased, particularly from 2012/13 (approximately 18%) to 2015/16 (just under 25%).

The average expenditure share spent on vehicles across quintiles is fairly stable over the time period (shown in panel c of Figure 7), with the lowest expenditure quintile having the lowest mean share, and the highest expenditure quintile having the highest expenditure share. When we only include households with a reported vehicle purchase, the average expenditure for a vehicle purchase increased from just over $10,000 in 2006/07 to just over $15,000 in 2018/19 (shown in panel *c* of Figure 7). For this group of households, the expenditure share for each quintile is fairly similar over the time period, and there is almost complete overlap in the confidence intervals for each of the quintiles, with the exception of the lowest quintile in 2012/13. This indicates that households in each quintile allocated a similar proportion of their budgets to a vehicle purchase (between 10-20% of their annual total household expenditure).

The cost of purchasing a vehicle includes the interest paid for financing it (i.e., loan interest). However, very few households reported interest paid on car loans (between 5-8% of households reported this type of expenditure). This may be due to households using other forms of financing (e.g., personal loans), but we were not able to distinguish these as being specific to vehicle purchases.

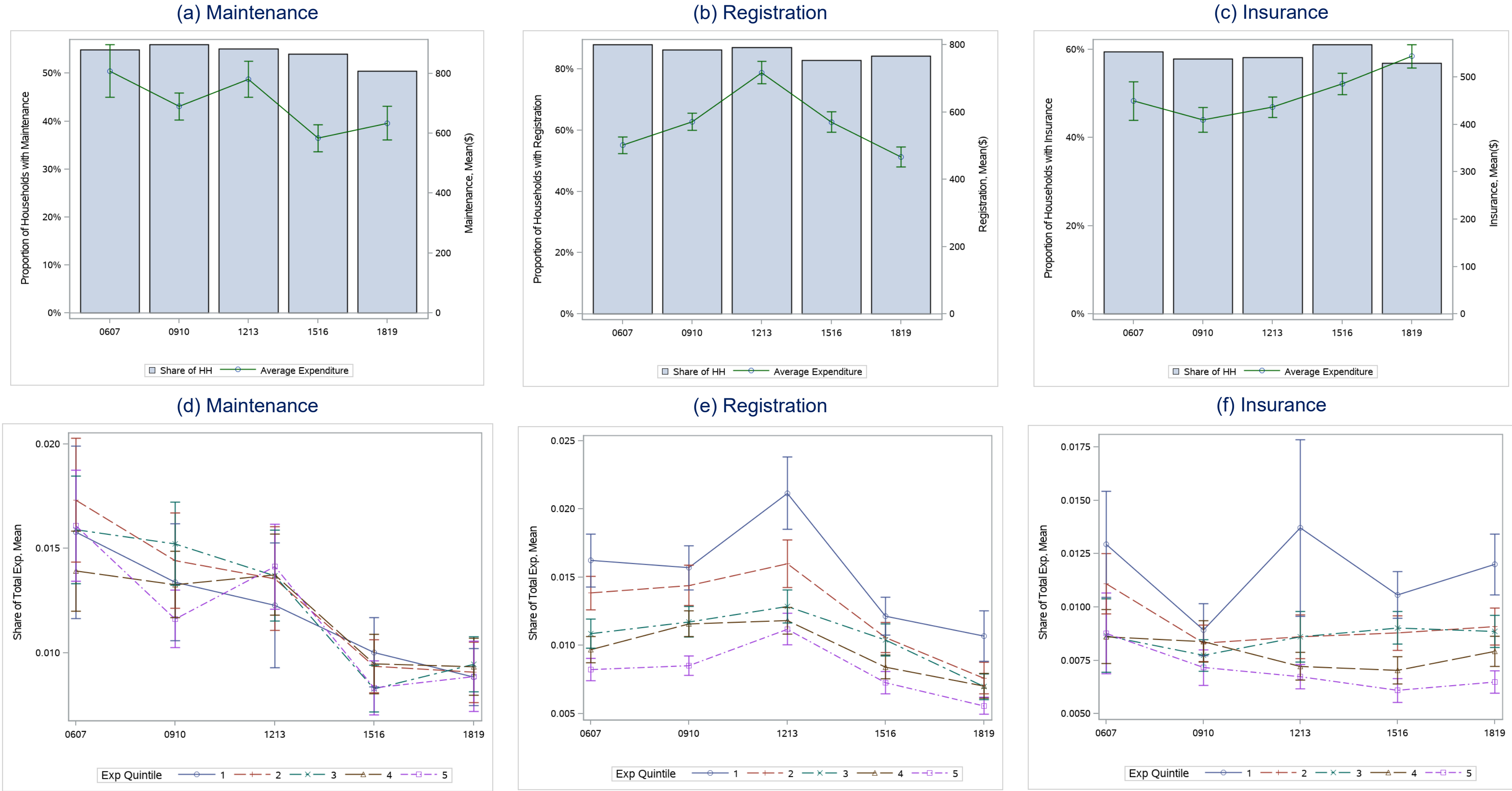
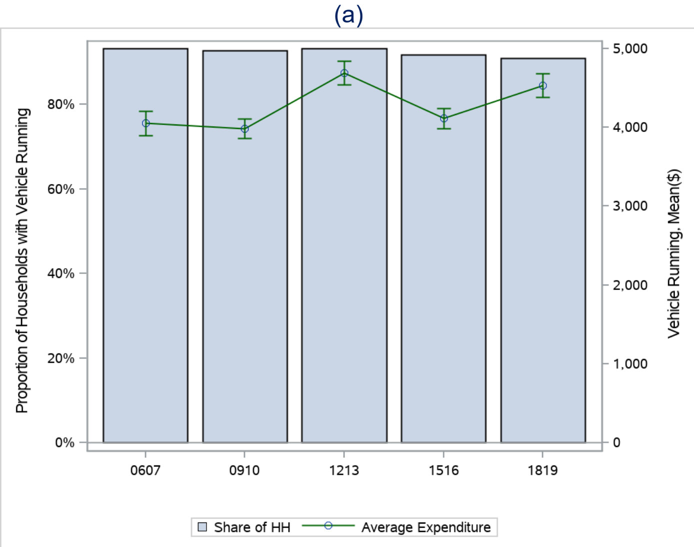


Figure 5: Household Expenditures for Other Vehicle Operating Costs

(a)



(b)

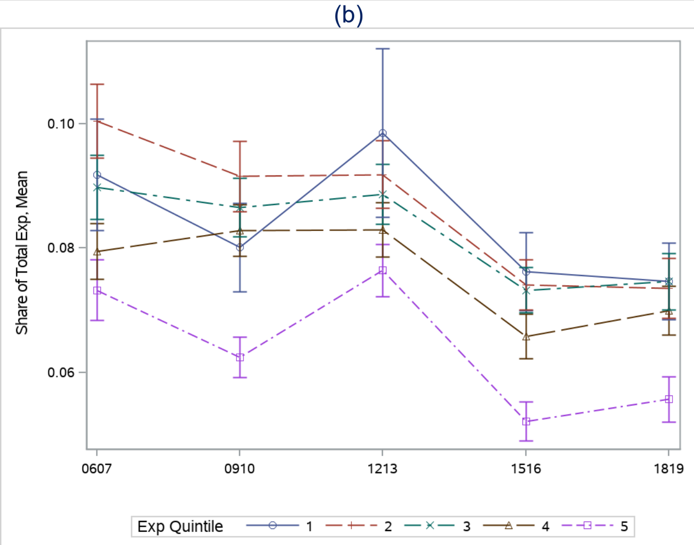


Figure 6: Household Expenditures for Vehicle Running Costs

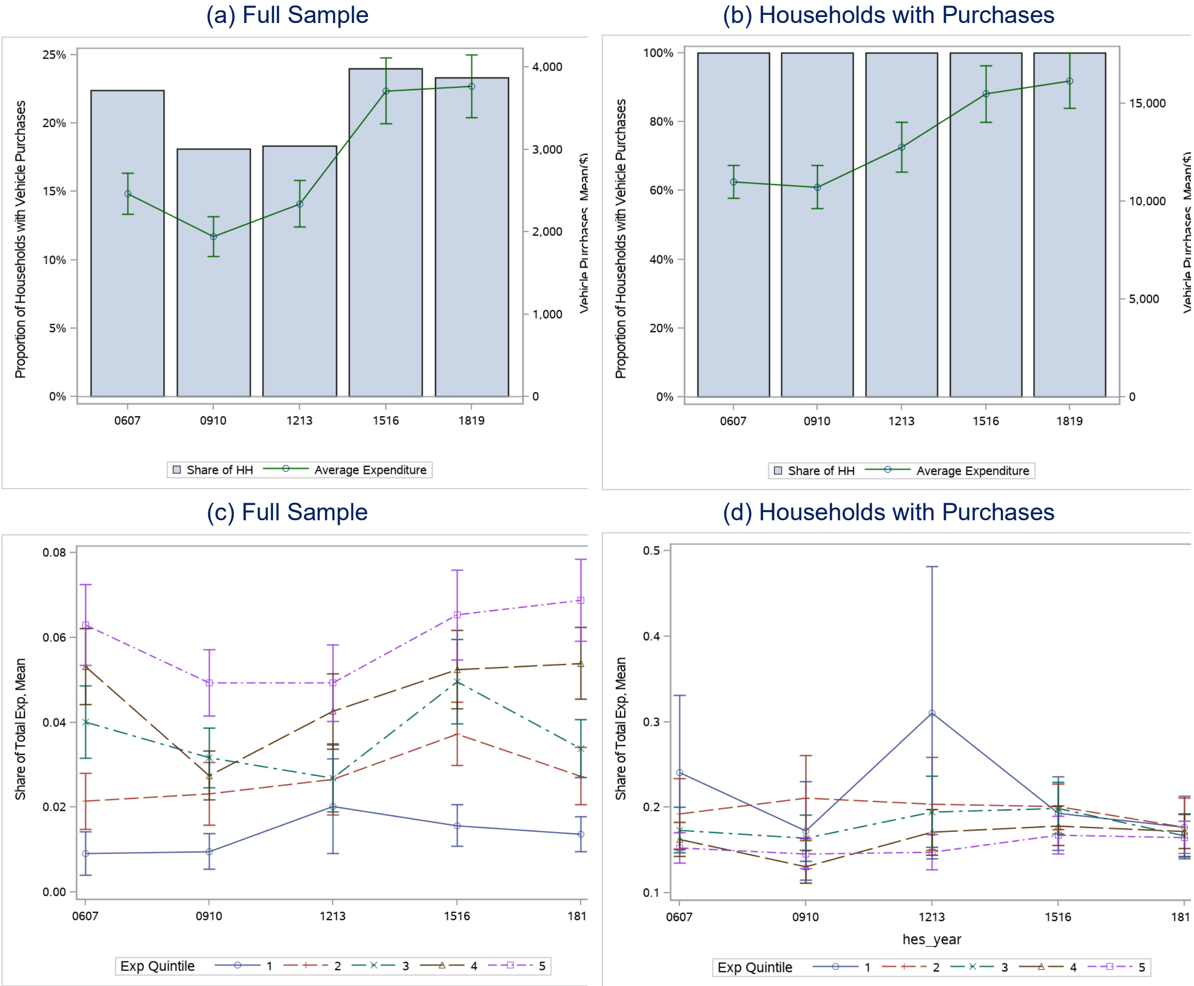


Figure 7: Household Expenditures for Private Vehicle Purchases

4.2.3 Public Transport

In Table 2, the average annual household expenditure for the full sample (across all years) was $180 with approximately 13% of households reporting positive public transport expenditures. However, conditional on reporting public transport expenditures, the average expenditure was $1,400. Looking at the underlying trends in these numbers over time, we see that the percentage of households reporting expenditures for public transport was highest in 2006/07 (about 15% of households) as shown in panel *a* of Figure 8, and as with fuel expenditures, it dropped fairly substantially in 2018/19 to about 10%.[39] From 2006/07 to 2015/16, however, this percentage was fairly steady ranging from 13% to 15%. The overall average annual expenditure in nominal terms for all households increased over this same time period, from $125 in 2006/07 to just under $250 in 2015/16. However, these averages conditional on reporting public transport expenditures were $800 in 2006/07 and $1,700 in 2015/16.

[39] Public transport expenditures also appear to be reported in the survey via the expenditure diary, so these expenditures are likely to be affected by the change from a 14-day diary to a 7-day diary in 2018/19. Hence, it is difficult to disentangle the effect of the survey change from behavioural changes.

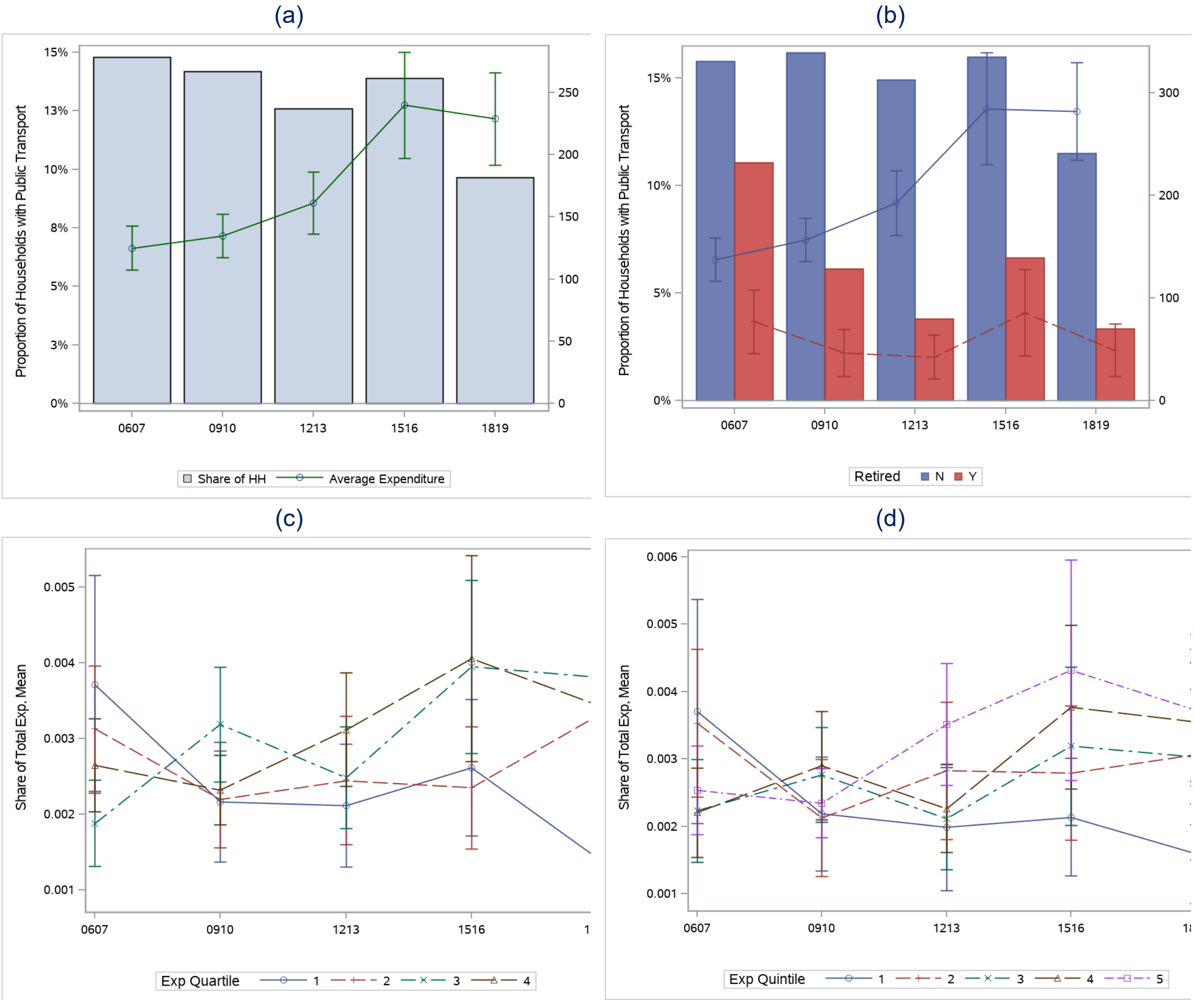


Figure 8: Household Expenditures for Public Transport

In examining households with at least one retiree (shown in panel *b* of Figure 8), there is a much more substantial decline in the proportion of households reporting public transport expenditures between 2006/07 (11%) and 2012/13 (around 4%), though in 2015/16, it rebounded up to about 6%.[40] The average annual expenditure amount for all retiree households was significantly lower than that for households without any retirees, and it remained fairly steady between 2006/07 and 2015/16. Conditional on having expenditures, however, the average retiree household spent approximately $600 annually on public transport in 2006/07 and $1,250 in 2015/16.

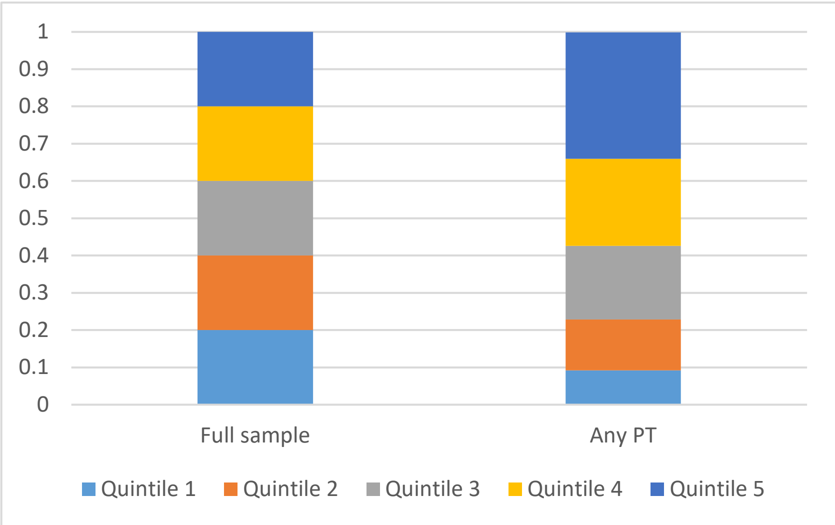
In terms of total expenditure share allocated to public transport (shown in panel *d* of Figure 8), the lowest quintile (EQ1) households went from having the highest mean share in 2006/07 to having the lowest mean share in 2018/19 with a significant decline over the time period. On the other hand, the highest quintile (EQ5) households went from having one of the lower mean shares in 2006/07 to having the highest mean share in 2018/19, with an increase over the

[40] The SuperGold Card was introduced in 2008 which allows free off-peak travel for those aged 65 years or older.

time period. However, there is a large degree of overlap in the confidence intervals for all quintiles indicating that the means across groups are not significantly different.

In Table 2, we report the percentage of households in each quintile with positive (i.e., non-zero) public transport expenditures as well as the average annual expenditure for all households in each quintile. From this, we can see that the percentage of households with positive public transport expenditures increases from the lowest quintile (6% of EQ1 households) to the highest quintile (22% of EQ5 households). The average household expenditure also increases over the quintiles – from $40 for the average EQ1 household to $400 for the average EQ5 household. Conditional on having public transport expenditures, the average for EQ1 households was $700 and $1,800 for EQ5 households.

(a) Expenditure Quintiles



(b) Household Income Quintiles

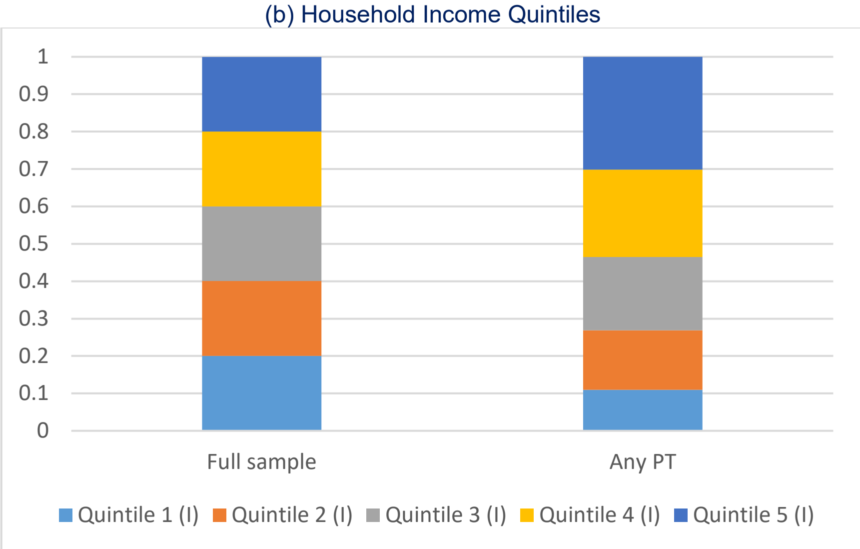


Figure 9: Proportion of Households with PT Expenditures, by Expenditure Quintile and Income Quintile

Looking at this in a slightly different way, Figure 9 shows the proportion of households with positive public transport expenditures within each quintile over all the survey years. Panel *a* shows the results by expenditure quintile, and panel *b* shows them by income quintile. Both panels show that the lowest two quintiles are disproportionately underrepresented in reporting positive public transport. Using the expenditure quintiles, 9% of the sample reporting public transport expenditures are in the lowest quintile (EQ1) and 14% are in the second quintile (EQ2). The two highest quintiles are overrepresented in those reporting positive public transport expenditures – 23% of these households are in EQ4, and 34% are in EQ5. Comparing the results using the expenditure quintiles to those using the income quintiles shows roughly similar results but with a dampening of the overall effect. For example, 11% of households reporting public transport expenditures were in the lowest income quintile (IQ1) and 16% were in the second income quintile (IQ2), whereas only 30% were in the highest income quintile (IQ5). Hence, using income quintiles finds a slightly larger percentage of lower-income households reporting public transport expenditures and a slightly lower percentage of high-income households.

Using the summary statistics from Table 2, we can also see differences in the characteristics of households in the full sample compared to those reporting positive public transport expenditures (the 'any-PTX sample'). For example, households in the any-PTX sample are more likely than the full sample to have the following characteristics:

- live in the Auckland region (44% *vs.* 31%) or in the Wellington region (24% *vs.* 11%);
- be coupled-parents (40% *vs.* 31%) or other household types (e.g., other one-family households, all other households);
- live in private rentals (30% *vs.* 24% for the full sample);

and less likely to …

- own their home (59% *vs.* 67% for the full sample);
- be in one-person (11% *vs.* 21%) or one-couple (15% *vs.* 27%) households; or
- have retirees (10% *vs.* 21%).

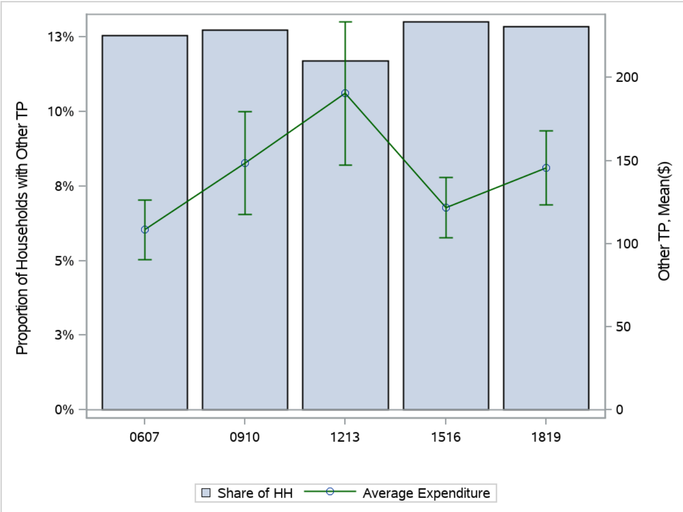
Somewhat surprisingly, households in the any-PTX sample were slightly more likely to have positive fuel expenditures (75% *vs.* 72% for the full sample) than the full sample and had slightly higher average annual fuel expenditures ($2,800 vs. $2,500).[41] So, in addition to having similar fuel expenditures to the full sample, the average household in the any-PTX sample also spent approximately $1,400 on public transport annually (about 2% of their total household expenditures).

[41] Even conditional on having fuel expenditures, households in the any-PTX sample also had slightly higher average fuel expenditures compared to the full sample ($3,700 *vs.* $3,400).

4.2.4 Other Transport

For cycling expenditures, a very small percentage of households reported positive expenditures, and this percentage declined fairly substantially between 2006/07 and 2018/19. Given the small number of households, we do not report other information about these expenditures.

(a)



(b)

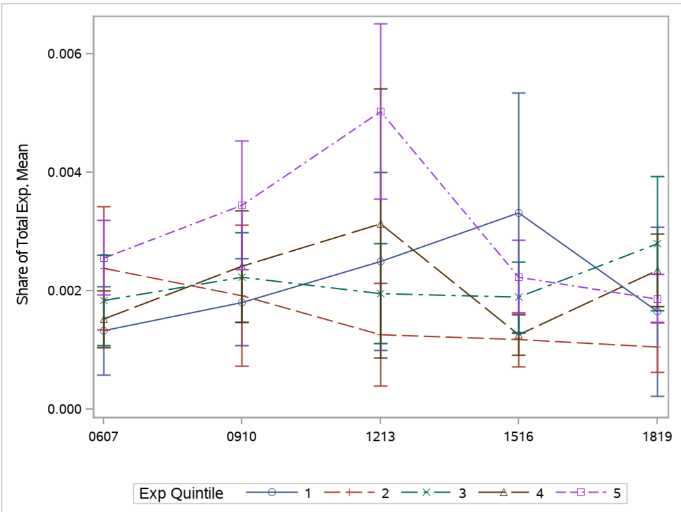


Figure 10: Household Expenditures for Other Transport Expenditures

Transport expenditures that were not otherwise classified were combined into ‘Other Transport’. This included other types of transport such as taxis, other private car services, rental cars. The percentage of households with these expenditures stayed around 13% across all survey years, and the average annual expenditure in this category was between $100 and $200 which increased steadily between 2006/07 and 2012/13, with a significant drop in 2015/16 followed by a slight increase in 2018/19 (as shown in panel a of Figure 10). In terms of total expenditure shares for this category (as shown in panel b of Figure 10), there is a fair amount of overlap in the confidence intervals for each quintile. However, in the first three survey years, households in EQ5 had the highest mean share, but then in 2015/16, their mean share dropped significantly putting them much closer to the mean shares of the other expenditure groups.

4.3 Regression Analysis: Likelihood of Expenditures

We first examine the likelihood that households have certain types of expenditures. In particular, we look at the likelihood that households reported positive transport expenditures on fuel, public transport, vehicle purchases, and vehicle sales. The results from the regression analysis may be similar to the results from examining our descriptive statistics. However, the regression analysis allows also to control for multiple, potentially confounding, factors, whereas the descriptive analysis only allows us to look at a few variables in combination (e.g., quintiles and years).

The key results from these regressions include the following:

- The likelihood of reporting fuel or public transport expenditures was significantly lower in 2018/19 relative to the other survey years.
- The following factors were associated with decreased reporting of fuel expenditures:
    - Higher petrol prices
    - Having at least one retiree in the household
    - Living in the Wellington region
    - Higher housing costs
    - Having public transport expenditures
- The following factors were associated with increased reporting of fuel expenditures:
    - Higher total household expenditure
    - Having a post-secondary qualification as the highest qualification in the household
    - Living further from an economic centre
- The following factors were associated with decreased reporting of public transport expenditures:
    - Higher petrol prices
    - Having at least one retiree in the household
    - Higher housing costs
    - Having fuel expenditures
    - Living further from an economic centre
- The following factors were associated with increased reporting of public transport expenditures:
    - Higher total household expenditure
    - Having a bachelor’s degree or higher as the highest qualification in the household
    - Living in a rental property (either public or private)
    - Living in the Wellington or Auckland regions
- Vehicle purchases were more likely when fuel prices were increasing but vehicle sales were less likely.

- Households in the Auckland, Canterbury, and Wellington regions were not significantly different in their likelihood to report a vehicle purchase, whereas households in other regions of the North and South Islands were more likely to report a vehicle purchase.

4.3.1 Fuel

The results for the logistic regressions related to fuel expenditures (FX) are shown in the first 6 columns of Table 5, with the first 3 columns showing results for the full sample and the next 3 columns showing results for the bottom two expenditure quintiles (the 'low-income' sample).

In all specifications that include the survey year variables, the coefficients for these variables are all negative, though not all are significant. These negative coefficients indicate that the likelihood of households reporting fuel expenditures was lower than in the base year (2006/07). Moreover, in both samples, households in 2018/19 had the most substantial and significant decrease in their likelihood of reporting fuel expenditures, which is not surprising given the results from the earlier sections. We also see the magnitude of the significant coefficients in the full sample increased over each subsequent year, which indicates that the likelihood of households reporting positive fuel expenditures was declining over the time period. For example, using the first specification for the full sample, the coefficient was -0.170 for 2009/10, -0.276 for 2015/16, and -1.048 for 2018/19.[42] In the low-income sample, the results indicate that the likelihood of these households reporting fuel expenditures was similar in the first three years of the survey and that any significant[43] decline for these households did not begin until 2015/16 or 2018/19 depending on the specification.

Adding the quarterly fuel price to the specification with the month and year controls resulted in an insignificant association (results not shown); however, without the month and year controls, the coefficient for the fuel price becomes negative and significant (shown in column 3 of Table 5) in both samples. Hence, multicollinearity appears to be problematic when including both fuel prices and the time controls, so we drop the time controls when using the petrol price.[44] These results indicate that higher petrol prices were associated with a significant reduction in the likelihood of reporting fuel expenditures.

Examining the household factors that affect the likelihood that reporting positive fuel expenditures, we find that the likelihood increases significantly over each quintile in the full sample with households in the highest quintile (EQ5) having the highest likelihood. Relative to households with no school qualifications, households with post-secondary qualifications in both samples are significantly more likely to have positive fuel expenditures. Household

[42] The specifications with year controls also included controls for interview month; however, we found very little significant variation across months in any specification. In other specifications not included in this report, we also used quarter controls instead of month controls but found no significant seasonal variation in these specifications either.
[43] Significant at the 5% level.
[44] This will be true for all the regressions included in this report.

composition is also a significant factor. Relative to one-person households, all other households were significantly more likely to report positive fuel expenditures in both samples. Moreover, households in public rentals were significantly less likely than those who own their homes to report positive fuel expenditures, though the results are much stronger for the low-income sample than for the full sample. Households in private rentals were not significantly different from homeowners in this respect in either sample. Households with at least one retiree were significantly less likely to report fuel expenditures than other households in both samples. The results for retirees reflect our earlier results, but the regression analysis allows us to control for other potential confounding factors.

Compared to households in Auckland, households in Wellington were significantly less likely to report fuel expenditures in the full sample. In the low-income sample, the coefficient for Wellington households was negative but not significant at the 5% level. These results indicate that low-income households in both regions are similar in their propensity to report fuel expenditures but that households in the full sample are not. Households in other regions did not differ significantly from Auckland households in this regard in either sample.

The relationship between the distance to the TAW centre and the likelihood of fuel expenditures is positive and significant in the full sample, but it is not significant in the low-income sample. These results indicate that being closer to an economic centre may have a different effect on fuel use for low-income households.

The relationship between housing costs and the likelihood of fuel expenditures is negative and significant in both samples, which means that increasing housing costs is associated with a reduced likelihood of fuel expenditures. There is also an inverse, significant relationship between the likelihood of public transport expenditures and the likelihood of fuel expenditures in both samples, which indicates that households with public transport expenditures are less likely to have fuel expenditures. Moreover, the magnitude of the coefficient in the low-income sample is about twice that of the full sample. These results differ from the descriptive results discussed in section 4.2.3, which shows the importance of controlling for other household factors.

Table 5: Logistic Regression of Fuel Expenditures (FX) and Public Transport Expenditures (PTX)

	FX (0/1)						PTX (0/1)					
	Full Sample			Low-Income Sample			Full Sample			Low-Income Sample		
Petrol Price (c/l)			-0.0104***			-0.00814***			-0.00545***			-0.00856***
			(0.000910)			(0.00128)			(0.00117)			(0.00224)
2009/10	-0.170**	-0.172**		-0.105	-0.117		-0.0626	-0.0718		-0.261	-0.278*	
	(0.0760)	(0.0759)		(0.104)	(0.104)		(0.0893)	(0.0892)		(0.162)	(0.162)	
2012/13	-0.100	-0.106		-0.102	-0.120		-0.216**	-0.217**		-0.396**	-0.402**	
	(0.0758)	(0.0758)		(0.103)	(0.103)		(0.0937)	(0.0938)		(0.172)	(0.174)	
2015/16	-0.276***	-0.279***		-0.184*	-0.202**		-0.0545	-0.0665		-0.455***	-0.479***	
	(0.0729)	(0.0729)		(0.0985)	(0.0990)		(0.0908)	(0.0910)		(0.164)	(0.166)	
2018/19	-1.048***	-1.062***		-0.895***	-0.928***		-0.546***	-0.602***		-0.926***	-1.037***	
	(0.0704)	(0.0707)		(0.0999)	(0.101)		(0.0951)	(0.0975)		(0.189)	(0.194)	
EQ2	0.882***	0.885***	0.879***	0.976***	0.993***	0.990***	0.236**	0.290**	0.240**	0.399***	0.527***	0.430***
	(0.0652)	(0.0652)	(0.0643)	(0.0698)	(0.0700)	(0.0694)	(0.119)	(0.119)	(0.119)	(0.131)	(0.133)	(0.130)
EQ3	1.251***	1.262***	1.249***				0.576***	0.649***	0.573***			
	(0.0751)	(0.0749)	(0.0741)				(0.122)	(0.124)	(0.123)			
EQ4	1.534***	1.550***	1.547***				0.709***	0.794***	0.701***			
	(0.0852)	(0.0854)	(0.0839)				(0.126)	(0.128)	(0.126)			
EQ5	1.855***	1.882***	1.911***				1.055***	1.151***	1.056***			
	(0.0985)	(0.0992)	(0.0996)				(0.131)	(0.133)	(0.130)			
Secondary	0.112	0.112	0.123*	0.136*	0.138*	0.145*	0.174	0.185	0.183	0.101	0.131	0.108
	(0.0718)	(0.0718)	(0.0705)	(0.0821)	(0.0822)	(0.0809)	(0.127)	(0.127)	(0.126)	(0.157)	(0.158)	(0.156)
Post-secondary	0.198***	0.196***	0.191***	0.267***	0.267***	0.260***	0.0750	0.0853	0.0765	0.0510	0.0975	0.0365
	(0.0733)	(0.0734)	(0.0721)	(0.0867)	(0.0869)	(0.0858)	(0.130)	(0.130)	(0.130)	(0.169)	(0.170)	(0.168)
Bachelor	0.109	0.121	0.0757	0.222*	0.251*	0.168	0.579***	0.587***	0.570***	0.682***	0.717***	0.637***
	(0.0870)	(0.0871)	(0.0856)	(0.128)	(0.129)	(0.127)	(0.135)	(0.135)	(0.134)	(0.211)	(0.212)	(0.212)

Post-grad	-0.0272	-0.00832	-0.0700	-0.263*	-0.232	-0.325**	0.728***	0.731***	0.722***	0.857***	0.844***	0.790***
	(0.0892)	(0.0895)	(0.0885)	(0.144)	(0.145)	(0.142)	(0.135)	(0.135)	(0.135)	(0.222)	(0.224)	(0.221)
Public Rental	-0.153*	-0.137*	-0.178**	-0.260***	-0.225**	-0.265***	0.722***	0.720***	0.694***	0.926***	0.905***	0.911***
	(0.0838)	(0.0830)	(0.0818)	(0.0974)	(0.0972)	(0.0955)	(0.122)	(0.121)	(0.123)	(0.168)	(0.168)	(0.166)
Private Rental	0.0604	0.0703	0.0832	0.0269	0.0426	0.0941	0.363***	0.367***	0.371***	0.500***	0.509***	0.555***
	(0.0571)	(0.0572)	(0.0563)	(0.0939)	(0.0943)	(0.0919)	(0.0731)	(0.0733)	(0.0734)	(0.171)	(0.173)	(0.172)
Any Maori	0.118*	0.117*	0.119*	0.117	0.118	0.124	0.00533	0.00820	0.00815	0.0355	0.0459	0.0563
	(0.0653)	(0.0650)	(0.0644)	(0.0901)	(0.0901)	(0.0884)	(0.0858)	(0.0857)	(0.0863)	(0.147)	(0.148)	(0.145)
Couple Only	0.399***	0.395***	0.378***	0.385***	0.378***	0.364***	-0.287***	-0.256**	-0.290***	-0.389**	-0.336*	-0.403**
	(0.0634)	(0.0635)	(0.0624)	(0.0796)	(0.0798)	(0.0784)	(0.110)	(0.110)	(0.111)	(0.170)	(0.173)	(0.168)
Coupled Parents	0.703***	0.712***	0.688***	0.570***	0.577***	0.559***	0.371***	0.416***	0.374***	0.141	0.235	0.151
	(0.0734)	(0.0737)	(0.0726)	(0.113)	(0.114)	(0.114)	(0.105)	(0.105)	(0.106)	(0.178)	(0.181)	(0.177)
Sole Parents	0.680***	0.694***	0.655***	0.638***	0.657***	0.625***	0.635***	0.679***	0.623***	0.399**	0.483***	0.406**
	(0.0857)	(0.0858)	(0.0841)	(0.103)	(0.104)	(0.103)	(0.122)	(0.122)	(0.123)	(0.166)	(0.169)	(0.165)
Other one-family	0.781***	0.802***	0.733***	0.538***	0.566***	0.525***	0.715***	0.763***	0.707***	0.470*	0.531*	0.480*
	(0.119)	(0.119)	(0.118)	(0.191)	(0.191)	(0.188)	(0.142)	(0.143)	(0.142)	(0.280)	(0.286)	(0.274)
All other HH	0.974***	0.996***	0.941***	0.599***	0.610***	0.572***	0.719***	0.773***	0.719***	0.195	0.274	0.235
	(0.114)	(0.115)	(0.114)	(0.172)	(0.173)	(0.167)	(0.131)	(0.131)	(0.132)	(0.248)	(0.250)	(0.245)
Retiree	-0.165***	-0.169***	-0.201***	-0.307***	-0.316***	-0.331***	-0.351***	-0.356***	-0.356***	-0.308**	-0.343**	-0.329**
	(0.0578)	(0.0579)	(0.0570)	(0.0733)	(0.0734)	(0.0723)	(0.102)	(0.102)	(0.102)	(0.151)	(0.152)	(0.150)
Canterbury	0.0256	0.0164	-0.00738	-0.0109	-0.0222	-0.0338	-0.328***	-0.325***	-0.340***	-0.166	-0.161	-0.209
	(0.0686)	(0.0686)	(0.0681)	(0.0983)	(0.0985)	(0.0980)	(0.0901)	(0.0900)	(0.0899)	(0.163)	(0.164)	(0.163)
North Island	0.0845	0.0651	0.0592	0.104	0.0755	0.0870	-1.028***	-1.026***	-1.031***	-0.881***	-0.870***	-0.920***
	(0.0621)	(0.0625)	(0.0614)	(0.0870)	(0.0871)	(0.0860)	(0.0919)	(0.0918)	(0.0917)	(0.163)	(0.163)	(0.162)
South Island	0.00967	-0.00736	-0.00914	0.00996	-0.0161	-0.00985	-0.849***	-0.850***	-0.850***	-0.819***	-0.822***	-0.858***
	(0.0731)	(0.0734)	(0.0725)	(0.102)	(0.102)	(0.102)	(0.106)	(0.106)	(0.106)	(0.192)	(0.192)	(0.191)
Wellington	-0.202***	-0.181***	-0.204***	-0.192*	-0.169	-0.186*	0.637***	0.628***	0.629***	0.525***	0.509***	0.514***
	(0.0679)	(0.0679)	(0.0672)	(0.102)	(0.103)	(0.102)	(0.0733)	(0.0734)	(0.0734)	(0.150)	(0.151)	(0.149)

Housing Costs	-1.72e-05***	-1.75e-05***	-2.16e-05***	-3.83e-05***	-3.94e-05***	-4.65e-05***	-8.59e-06***	-9.26e-06***	-9.77e-06***	-2.95e-05**	-3.48e-05***	-3.77e-05***
	(2.54e-06)	(2.55e-06)	(2.52e-06)	(7.03e-06)	(7.06e-06)	(6.84e-06)	(2.79e-06)	(2.80e-06)	(2.76e-06)	(1.28e-05)	(1.29e-05)	(1.24e-05)
Dist to TAW (min)	0.00519**	0.00503**	0.00474**	0.00444	0.00409	0.00429	-0.0144***	-0.0141***	-0.0151***	-0.0227***	-0.0219***	-0.0220***
	(0.00212)	(0.00212)	(0.00207)	(0.00278)	(0.00279)	(0.00271)	(0.00450)	(0.00449)	(0.00457)	(0.00731)	(0.00716)	(0.00714)
PTX (0/1)		-0.240***			-0.506***							
		(0.0688)			(0.116)							
FX (0/1)								-0.261***			-0.530***	
								(0.0707)			(0.118)	
Observations	16146	16146	16146	6846	6846	6846	16146	16146	16146	6846	6846	6846
R-squared	0.130	0.131	0.115	0.0982	0.101	0.0853	0.137	0.138	0.133	0.113	0.120	0.104

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.3.2 Public Transport

The results of the logistic regressions for the likelihood of positive public transport expenditures are shown in the right half of Table 5 – columns 7-9 use the full sample and columns 10-12 use households in the low-income sample. We found that relative to our base year (2006/07), households in 2012/13 and 2018/19 were significantly less likely to have public transport expenditures (PTX) in the full sample. In the low-income sample, the coefficients for all years were negative and significant at the 5% level in the last three survey years. Moreover, the coefficients do not change much as we add other variables.[45] Using the petrol price in place of the year and month controls yields a coefficient on the price variable which is negative and significant in both samples.

A number of household characteristics were also significant factors contributing to the likelihood that households have PTX. When looking at quintiles, we find that, compared to the lowest quintile (EQ1), the higher quintiles are associated with an increased likelihood of having PTX. Moreover, the likelihood increases significantly for each subsequent quintile (i.e., the coefficient for EQ2 is significantly greater than the coefficient for EQ3). These results indicate that households are more likely to report PTX as household income increases.

In both samples, the highest education level in the household is a significant factor in the likelihood that the household has PTX – those with a university or post-graduate qualification were significantly more likely to report public transport expenditures than those with no qualifications. In both samples, renters were significantly more likely to have PTX than homeowners, and households in public rentals are significantly more likely to have PTX than those in private rentals. Households with at least one retired person were also less likely to have PTX than those without.[46]

The location of the dwelling and the housing costs also significantly affected households' likelihood of having public transport expenditures. First, the region makes a difference. Compared to Auckland, only Wellington households were significantly more likely to have PTX in both samples, whereas households on the rest of the north island were significantly *less* likely to have PTX. There is also a significant and negative relationship between the distance (in minutes) to the closest TAW centre[47] and PTX as well as between housing costs and PTX in both samples.

[45] As with fuel expenditures, the specifications reported included month controls, but we did not generally find significant variation across months. In unreported specifications, we also used quarterly controls, but in these we also did not find any significant seasonal variation.
[46] The SuperGold Card was introduced in 2008 which allows free off-peak travel for those aged 65 years or older. Hence, this would affect the likelihood of retirees reporting public transport expenditures.
[47] In unreported specifications, we also used distance to the closest city in place of distance to the closest TAW centre, but the results were similar.

4.3.3 Private Vehicle Purchases and Sales

Table 6 shows the results for the logistic regressions using the binary variables for households with private vehicle purchases and sales. The first two columns have private vehicle purchases as the dependent variable, and the second two columns have private vehicle sales as the dependent variable. For each dependent variable, the specifications differ in the use of time controls (month[48] and year) as opposed to the petrol price. Given the high correlation between the petrol price and the time controls, collinearity was problematic when we included both, so we only report specifications using these separately.

There is a significant and positive relationship between the likelihood of private vehicle purchases and sales, which indicates that households are more likely to sell a car when they purchase one. Vehicle purchases were less likely in 2009/10 and 2012/13 compared to the base year (2006/07); however, vehicle purchases were more likely in 2015/16 and 2018/19 than in 2006/07. On the other hand, vehicle sales in 2009/10 and 2012/13 were not significantly more likely relative to 2006/07 but significantly less likely in 2015/16 and 2018/19. When using the petrol price in place of the month and year controls, the coefficient was significant and positive when the dependent was for vehicle purchases, whereas the coefficient for significant and negative when the dependent was for vehicles sales. This indicates that vehicle purchases were more likely when fuel prices were increasing but vehicle sales were less likely.

Household characteristics are more significant factors in the likelihood of vehicle purchases than in the likelihood of vehicle sales. For example, the likelihood of a vehicle purchase is significantly more likely for EQ2-EQ5 compared to EQ1, and the coefficient for each expenditure increases for each subsequent quintile; however, there is no significant difference between quintiles in the likelihood of vehicle sales.

Households with educational qualifications were significantly less likely than households with no educational qualifications (base group) to report a vehicle purchase, but there was little difference across educational qualifications in this likelihood (i.e., the coefficients for these different groups were not significantly different from each other). For vehicle sales, households with educational qualifications were more likely than households with no educational qualifications to report a vehicle sale, but again, there do not appear to be significant differences across educational qualifications.

[48] As with the previous regressions, we included month controls in the reported specifications, but we did not find any significant results, so we do not report the coefficients for the months. There does not appear to be significant seasonality in purchases or sales.

For household composition,[49] there was no significant difference between the likelihood of a vehicle purchase for one-person, one-couple, and sole-parent households. Coupled parents were more likely to report a vehicle purchase than a one-person household. Other one-family and ‘all other households’ were significantly more likely to report a vehicle purchase. For vehicle sales, there was no significant difference between these different household types, though the coefficient for ‘all other households’ was negative and significant at the 10% level when we used the petrol price as opposed to year and month controls. Renters were significantly more likely to report a vehicle purchase then homeowners, but the likelihood of a vehicle sale was not significantly different between renters and homeowners. Households with retirees were significantly less likely to report a vehicle purchase not significantly different from other households in reporting a vehicle sale.

Households in the Auckland, Canterbury, and Wellington regions were not significantly different in their likelihood to report a vehicle purchase, whereas households in other regions of the North and South Islands were more likely to report a vehicle purchase. For vehicle sales, every region was more likely to report vehicle sales than Auckland; however, households in Canterbury were significantly more likely than any other region to report a vehicle sale.

The distance to a TAW centre was not significantly associated with the likelihood of a vehicle purchase or sale. Housing costs were significantly and negatively associated with the likelihood of a vehicle purchase and a vehicle sale.[50] This indicates that households with higher housing costs are less likely to purchase or sell a vehicle.

Table 6: Logistic Regression of Vehicle Purchases and Sales

	Vehicle Purchases (0/1)		Vehicle Sales (0/1)	
Vehicle Sale	3.142*** (0.106)	3.067*** (0.102)		
Vehicle Purchase			3.157*** (0.106)	3.078*** (0.103)
Petrol Price (c/l)		0.00277** (0.00112)		-0.00537*** (0.00170)
2009/10	-0.287*** (0.0913)		-0.0834 (0.125)	
2012/13	-0.239** (0.0947)		-0.0297 (0.125)	
2015/16	0.393*** (0.0855)		-0.866*** (0.135)	
2018/19	0.358***		-0.730***	

[49] We also replaced the household composition variable with a measure of household size (number of individuals in the household. Household size was significantly and positively associated with the likelihood of a vehicle purchase and negatively, though not significantly, associated with the likelihood of a vehicle sale.
[50] The coefficient on housing costs was not significant in both specifications for vehicle sales – it was only significant in the specification using the petrol price.

	(0.0845)		(0.130)	
EQ2	0.802***	0.781***	0.0452	0.0536
	(0.120)	(0.119)	(0.173)	(0.174)
EQ3	1.282***	1.245***	0.111	0.150
	(0.125)	(0.124)	(0.182)	(0.184)
EQ4	1.772***	1.709***	0.136	0.219
	(0.127)	(0.126)	(0.187)	(0.187)
EQ5	2.423***	2.324***	0.174	0.298
	(0.132)	(0.131)	(0.195)	(0.195)
Secondary	-0.202*	-0.232**	0.587***	0.618***
	(0.108)	(0.107)	(0.171)	(0.168)
Post-secondary	-0.264**	-0.280***	0.646***	0.652***
	(0.108)	(0.107)	(0.171)	(0.168)
Bachelor	-0.386***	-0.364***	0.668***	0.621***
	(0.118)	(0.117)	(0.190)	(0.187)
Post-grad	-0.397***	-0.370***	0.662***	0.623***
	(0.123)	(0.122)	(0.198)	(0.193)
Public Rental	0.505***	0.480***	-0.218	-0.240
	(0.115)	(0.114)	(0.185)	(0.184)
Private Rental	0.537***	0.503***	-0.0757	-0.0512
	(0.0704)	(0.0697)	(0.108)	(0.108)
Any Maori	0.170**	0.174**	-0.0513	-0.0642
	(0.0743)	(0.0743)	(0.116)	(0.116)
Couple Only	0.151	0.155	-0.0303	-0.0393
	(0.0975)	(0.0965)	(0.137)	(0.137)
Coupled Parents	0.201**	0.209**	-0.0397	-0.0712
	(0.0990)	(0.0983)	(0.147)	(0.146)
Sole Parents	0.00940	0.0104	-0.0700	-0.0678
	(0.120)	(0.119)	(0.187)	(0.189)
Other one-family	0.328**	0.315**	-0.127	-0.124
	(0.133)	(0.133)	(0.199)	(0.197)
All other HH	0.466***	0.476***	-0.324	-0.363*
	(0.133)	(0.131)	(0.202)	(0.199)
Retiree	-0.441***	-0.391***	0.0726	-0.00883
	(0.0847)	(0.0845)	(0.122)	(0.121)
Canterbury	0.0435	0.0617	0.921***	0.871***
	(0.0858)	(0.0855)	(0.130)	(0.128)
North Island	0.253***	0.279***	0.717***	0.672***
	(0.0734)	(0.0729)	(0.121)	(0.120)
South Island	0.211**	0.233***	0.381***	0.332**
	(0.0902)	(0.0899)	(0.142)	(0.141)
Wellington	-0.0977	-0.0930	0.557***	0.530***
	(0.0871)	(0.0868)	(0.141)	(0.140)
Housing Costs	-1.09e-05***	-6.36e-06***	-5.60e-06	-1.17e-05***
	(2.48e-06)	(2.33e-06)	(4.16e-06)	(4.15e-06)
Dist to TAW (min)	-0.00143	-0.00126	0.00903*	0.00839*
	(0.00293)	(0.00292)	(0.00465)	(0.00470)
Observations	16,146	16,146	16,146	16,146
R-squared	0.212	0.202	0.288	0.275

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.4 Regression Analysis: Factors influencing Expenditure

We now examine the factors that affect the amount of various household expenditures. In particular, we look at transport fuel expenditures and public transport expenditures. We analyse these expenditures in three forms: in straight levels, in logs, and as a share of total expenditures. When analysing expenditures in levels, we examine expenditures for all households including those with zero expenditures. Analysing expenditures in logs allows us to examine changes in percentage terms, but these estimates are conditional on having positive expenditures. The share of expenditures allows us to examine the factors that influence households' budget allocations to a particular expenditure. For these regressions, we use generalised linear regression with robust standard errors, and observations are weighted using HES household survey weights.

The key findings from fuel regressions include the following:

- Fuel expenditures in 2015/16 were significantly lower than they were in 2012/13 or in 2018/19 which likely reflects lower fuel prices in 2015/16.
- Higher fuel prices were associated with higher fuel expenditures, but the fuel price did not significantly affect the share of households' budgets allocated to fuel.
- Higher-expenditure households spent significantly more on fuel than lower-expenditure households, but the highest two quintiles allocated a significantly smaller share of their total expenditure to fuel than the lowest three quintiles.
- Households with a post-secondary degree as the highest qualification spent significantly more on fuel than other households, and they allocated a significantly larger share of the total expenditures to fuel.
- Households in rentals (both public and private) tended to have lower fuel expenditures conditional on having fuel expenditures, but only households in public rentals allocated a significantly smaller share of their household budget to fuel.
- Households with retirees spent significantly less on fuel than other households and allocated a significantly smaller share of their total household budget to fuel.
- As housing costs increase, households spend less on fuel and allocate a smaller share of their total household budget to fuel.
- As households' distance from an economic centre increased, their fuel expenditures also increased as did the share of their budget allocated to fuel.
- Households with and without public transport expenditures spent similar amounts on fuel, conditional on having fuel expenditures. Households with public transport expenditures, however, allocated a significantly smaller share of their total expenditures to fuel.

The key findings from the public transport expenditure regressions include the following:

- As petrol prices increased, households spent more on public transport.
- Higher-expenditure households spent significantly more on public transport than lower-expenditure households; however, households in all the expenditure quintiles allocated similar shares of their budget to public transport.
- Households in public rentals allocated a significantly larger share of their household budget to public transport than other households.
- Conditional on having public transport expenditures, spending on public transport increased as the distance from an economic centre increased.

4.4.1 Fuel

We start by analysing total fuel expenditures (in levels) with results shown in columns 1 and 2 of Table 7. From this, we find that household expenditures in 2012/13, 2015/16, and 2018/19 were significantly higher than expenditures in the base year (2006/07), which is expected given that we use expenditures in nominal terms (results shown in column 1). Expenditures in 2015/16 were, however, significantly lower than they were in 2012/13 and in 2018/19 which likely reflects lower fuel prices in 2015/16.[51] We also included controls for interview month, but none of the coefficients were significant at the 5% level.[52]

As with our likelihood regressions, we use the average quarterly petrol price instead of our year and month controls and find that the coefficient is positive and significant, with a one cent increase in the price of regular petrol increasing average annual fuel expenditures by approximately $10 (results shown in column 2). This indicates that as fuel prices increase, households increase their total expenditures. Both specifications otherwise have similar results. Hence, we will focus on the results shown in column 1 of Table 7 for the discussion.

In terms of household characteristics, we find the following. The coefficients on the three highest expenditure quintiles are positive and significant,[53] compared to the lowest expenditure quintile. The coefficient increases significantly over each subsequent quintile with households in EQ2 spending approximately $680 more annually, in EQ3 spending $1,380 more annually, households in EQ4 spending $2,100 more annually, and households in EQ5 spending $3,120 more annually than households in the base group (EQ1). Given that the coefficients are significantly different across quintiles, higher-income households spent significantly more on fuel than lower-income households.

[51] The average price of regular petrol for the HES survey period was $2.00 per litre in 2015/16 compared to $2.33 per litre in 2012/13 or to $2.22 per litre in 2018/19 as shown in Table 1. Prices are from MBIE.
[52] We do not report all of the coefficients on the month controls. We include the coefficient for May given its significance in the other specifications.
[53] Using income quintiles instead of expenditure quintiles produces similar results in terms of sign and significance; however, the coefficients on the income quintiles are substantially smaller in magnitude.

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Table 7: Regression Analysis of Expenditures on Vehicle Fuel and Lubricants

	(1) Fuel Expenditures ($)	(2) Fuel Expenditures ($)	(3) Fuel Expenditures (LN)	(4) Fuel Expenditures (LN)	(5) Fuel Expenditures (SH)	(6) Fuel Expenditures (SH)
Petrol Price (c/l)		10.26***		0.00677***		2.47e-05
		(1.047)		(0.000328)		(2.16e-05)
2009/10	42.53		0.0686***		-0.00228	
	(69.87)		(0.0250)		(0.00154)	
2012/13	534.7***		0.264***		0.00277	
	(79.20)		(0.0248)		(0.00174)	
2015/16	249.4***		0.198***		-0.00604***	
	(72.65)		(0.0245)		(0.00147)	
2018/19	683.7***		0.598***		-0.00223	
	(86.62)		(0.0256)		(0.00165)	
May	-197.9*		-0.0707**		-0.00430**	
	(116.5)		(0.0335)		(0.00197)	
EQ2	682.8***	678.2***	0.289***	0.287***	0.000433	0.000507
	(50.38)	(50.33)	(0.0275)	(0.0279)	(0.00230)	(0.00231)
EQ3	1,377***	1,365***	0.516***	0.515***	-0.00259	-0.00252
	(69.22)	(69.07)	(0.0292)	(0.0297)	(0.00255)	(0.00256)
EQ4	2,105***	2,093***	0.684***	0.682***	-0.00721***	-0.00697***
	(86.93)	(85.99)	(0.0310)	(0.0313)	(0.00267)	(0.00266)
EQ5	3,123***	3,094***	0.882***	0.863***	-0.0137***	-0.0133***
	(118.6)	(116.5)	(0.0352)	(0.0352)	(0.00279)	(0.00276)
Secondary	-63.92	-68.88	-0.0175	-0.0260	0.00150	0.00170
	(61.57)	(61.39)	(0.0283)	(0.0285)	(0.00187)	(0.00188)
Post-secondary	219.2***	220.0***	0.0557**	0.0536*	0.00669***	0.00669***
	(67.13)	(66.99)	(0.0282)	(0.0283)	(0.00199)	(0.00199)
Bachelor	62.98	54.72	0.0266	0.0298	0.00310	0.00231
	(91.92)	(91.83)	(0.0329)	(0.0331)	(0.00207)	(0.00206)
Post-grad	-123.4	-139.9	0.0131	0.0150	-0.000243	-0.00123
	(94.07)	(93.87)	(0.0333)	(0.0336)	(0.00201)	(0.00200)
Public Rental	-78.65	-93.47	-0.0655**	-0.0636*	-0.00566***	-0.00625***
	(78.33)	(78.69)	(0.0331)	(0.0331)	(0.00189)	(0.00191)

Private Rental	-24.86	-44.47	-0.0690***	-0.0843***	-0.00208	-0.00224*
	(69.34)	(68.79)	(0.0203)	(0.0205)	(0.00134)	(0.00136)
Any Maori	53.73	50.92	-0.00933	-0.0102	0.00157	0.00152
	(70.29)	(70.94)	(0.0221)	(0.0225)	(0.00158)	(0.00162)
Couple Only	326.6***	332.4***	0.144***	0.145***	0.0106***	0.0106***
	(54.07)	(54.25)	(0.0238)	(0.0243)	(0.00165)	(0.00165)
Coupled Parents	758.9***	749.0***	0.223***	0.218***	0.0161***	0.0158***
	(67.11)	(67.64)	(0.0261)	(0.0265)	(0.00198)	(0.00200)
Sole Parents	479.7***	463.8***	0.0360	0.0387	0.0102***	0.00984***
	(79.15)	(79.08)	(0.0325)	(0.0328)	(0.00204)	(0.00205)
Other one-family	1,055***	1,041***	0.256***	0.265***	0.0200***	0.0197***
	(137.0)	(137.1)	(0.0379)	(0.0384)	(0.00239)	(0.00240)
All other HH	1,385***	1,375***	0.351***	0.349***	0.0246***	0.0244***
	(132.9)	(132.7)	(0.0370)	(0.0373)	(0.00251)	(0.00253)
Retiree	-179.3***	-179.1***	-0.0848***	-0.0719***	-0.00763***	-0.00805***
	(59.23)	(59.26)	(0.0214)	(0.0216)	(0.00145)	(0.00146)
Canterbury	-160.7*	-164.9*	-0.0876***	-0.0801***	-0.00365***	-0.00380***
	(84.36)	(84.79)	(0.0246)	(0.0247)	(0.00138)	(0.00139)
North Island	-128.8*	-114.6	-0.0903***	-0.0747***	-0.00174	-0.00149
	(71.04)	(70.13)	(0.0215)	(0.0216)	(0.00138)	(0.00137)
South Island	-228.4***	-224.3***	-0.106***	-0.0998***	-0.00477***	-0.00469***
	(82.35)	(82.03)	(0.0249)	(0.0252)	(0.00153)	(0.00153)
Wellington	-496.4***	-516.7***	-0.170***	-0.169***	-0.00908***	-0.00959***
	(73.18)	(73.94)	(0.0233)	(0.0237)	(0.00122)	(0.00122)
Housing Costs	-0.0187***	-0.0181***	-3.95e-06***	-2.57e-06***	-4.27e-07***	-4.70e-07***
	(0.00428)	(0.00413)	(9.13e-07)	(8.54e-07)	(4.09e-08)	(4.00e-08)
Dist to TAW (min)	13.66***	13.91***	0.00411***	0.00438***	0.000300***	0.000298***
	(2.346)	(2.384)	(0.000783)	(0.000807)	(5.24e-05)	(5.32e-05)
PTX (0/1)	-188.8**		-0.0433*		-0.00510***	
	(79.46)		(0.0234)		(0.00118)	
Observations	16,146	16,146	11,217	11,217	16,146	16,146
R-squared	0.215	0.212	0.266	0.248	0.061	0.054

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

The coefficients on our measures of highest qualification are largely insignificant with the exception of households with post-secondary qualifications. These results are similar to the results from the logistic regressions, where households with post-secondary qualifications were significantly more likely than households in the other groups to report fuel expenditures. The coefficient for post-secondary qualifications is positive and significant, with this group spending approximately $220 more annually than the other groups.

Relative to one-person households (the base group), we find that all other households had significantly higher-expenditures. Couples without children spent approximately $330 more annually, on average, than one-person households, and couples with children and other one-family households spent approximately $750 and $1,100 more annually, respectively compared to one-person households. Households with at least one retiree had significantly lower-expenditures than those without a retiree (approximately $180 less annually).

In terms of location, we find that households in the Wellington region and households on the South Island had significantly[54] lower fuel expenditures compared to those in Auckland (the base group), with households in Wellington having the largest coefficient in terms of absolute magnitude. Wellington households spent about $500 less annually than households in Auckland, and households on the South Island spent approximately $230 less annually than households in Auckland.

The coefficient on the distance measure (minutes to the nearest TAW centre) was positive and significant coefficient in both specifications, indicating that a one-minute increase in a household's distance from the centre was associated with a $14 increase in annual fuel expenditures. Our measure of housing costs has a negative and significant coefficient indicating that households with higher housing costs spent significantly less on fuel annually. Households with public transport expenditures (compared to those without) had lower fuel expenditures – approximately $190 less annually.

The results of our regressions using log expenditures yielded similar patterns and trends (results shown in columns 3 and 4 of Table 7) to those using the levels. It is important to remember that results using logged expenditures are conditional on households having expenditures which means using households with non-zero values only.[55]

In contrast to the results using the level of expenditures, the coefficients on all survey years are positive and significant relative to 2006/07, with annual expenditures in 2018/19 being the

[54] We are only considering significance at the 5% level. The coefficients for the North Island are significant at the 10% level in the specification in column 1 and insignificant in the specification in column 2. The coefficients for Canterbury in both specifications are significant at the 10% level.
[55] This is further enforced by the drop in the number of observations from approximately 16,000 households to approximately 11,000 households.

highest – approximately 82% higher[56] than spending in 2006/07. In the other years, the range is between 7% and 22% higher than in 2006/07. Our coefficient for households interviewed in May (relative to June) is significant and negative indicating that expenditures are about 7% lower in May compared to June (the base category). As with the specifications in columns 1 and 2, we separately estimate the log expenditure regressions with the petrol price measure in place of the month and year controls. The coefficient on the petrol price is positive and significant indicating that a one cent increase in the price raises expenditures by less than 1% (shown in column 4).

For households in the different expenditure quintiles, the results are similar to those shown in columns 1 and 2, with households in the higher-expenditure quintiles spending significantly more on fuel than the lowest expenditure quintile (EQ1) and each subsequent quintile spending more on fuel than the previous (33%, 68%, 98%, and 142% more, respectively, than the lowest expenditure quintile).

For household demographics, we find that renters had significantly lower fuel expenditures than homeowners – about 6% lower for households in public rentals[57] and between 7 and 9% lower for those in private rentals. For household composition, the coefficient for sole-parent households was insignificant when using the log of fuel expenditures, which means that conditional on having fuel expenditures, sole-parent and one-person households had similar expenditures. All the other household types had significantly higher fuel expenditures than one-person households. Households with at least one retiree had significantly lower fuel expenditures, approximately 8% less, compared to households with no retirees.

Households in all the regions had significantly lower-expenditures compared to households in Auckland when using logged expenditures as the dependent variable. Households in Wellington had significantly lower fuel expenditures (approximately 16%) compared to households in Auckland, whereas households in the rest of the country had significantly lower fuel expenditures on the order of 8-11%.

As with the specifications shown in columns 1 and 2, the coefficient on housing costs is negative and significant, and the coefficient on the distance to the TAW centre is positive and significant. The coefficient for households having public transport expenditures (shown in

[56] Because the dependent variable is the logged value of expenditure, we use the exponentiated coefficient to calculate the difference in expenditures in percentage terms (e.g., the exponentiated coefficient for 2018/19 is EXP(0.598)=1.82).

[57] The coefficient for households in public rentals is significant at the 5% level in the specification in column 3 but only significant at the 10% level in the specification in column 4.

Table 7) is negative but insignificant at the 5% level.[58] Hence, households with and without public transport spend similar amounts on fuel, conditional on having fuel expenditures. This is different from the result using the level of expenditure (reported in column 1).

The next set of specifications shown in columns 5 and 6 of Table 7 used the share of total expenditures households spent on fuel as the dependent variable, and the results using this share reveal very different patterns than those shown in the first four columns. First, only the coefficient on 2015/16 is significant (with a negative sign) – the coefficients for all the other years are insignificant. This result indicates that lower fuel prices in 2015/16 may have significantly lowered the share of the household budget spent on fuel. Second, the coefficient on the price of petrol while positive is not significant (shown in column 6), which indicates that, over the whole time period, price did not significantly impact the share of a household's budget allocated to fuels.[59]

Third, the coefficients on expenditure quintiles are only significant for the fourth and fifth quintiles (relative to the first quintile), whereas in the previous specifications, they were significant for all quintiles. Moreover, the coefficients on the third, fourth and fifth quintiles are now negative, which indicates that despite having higher expenditures in total, these households spent less of their total budget on fuel than households in the lower two quintiles given the current set of controls. Households in public rentals also allocate a significantly smaller share of their budget to fuel than homeowners.

Another difference is in the regional coefficients – the coefficient for households on the North Island (outside of Wellington and Auckland) is insignificant in both specifications which indicates that their fuel share is similar to Auckland households. The coefficients for all the other regions are negative and significant. Finally, the coefficient on the binary measure of public transport expenditures is now strongly significant, indicating that households with these expenditures allocate a smaller share of their total expenditures to fuel.

4.4.2 Public Transport

As with fuel expenditures, we start by examining the amount of public transport expenditures (PTX) for all households as shown in Table 8, with the first two columns showing the results for the level of PTX expenditures, the second two columns (columns 3 and 4) showing the results for the log of PTX expenditures, and the last two columns (columns 5 and 6) showing

[58] The coefficient is significant at the 10% level, but we are only considering significance at the 5% level. In unreported specifications, we also included different measures of public transport expenditures (i.e., the amount, the logged amount), but the coefficients were also insignificant at the 5% level for these measures.
[59] This may seem contradictory to our interpretation of the results on the year controls. However, the price measure averages across all time periods whereas the year controls allow for better isolation of the year effects. These results together could imply that the lower prices in 2015/16 were relative to higher prices in 2012/13 and that had a different effect than the lower price levels in the first two survey years.

the results for the share of total expenditures spent on PTX. Starting in column 1, the coefficient on PTX in all years, except 2009/10, is significant and positive relative to 2006/07. For this dependent variable, we find no evidence of seasonality over months, so while we controlled for interview month, we do not report the coefficients on all the month variables.

When using the average price of petrol (without month and year controls) in the model, we find that increasing fuel prices significantly increased PTX. With every one cent increase in the fuel price, PTX increased by about one dollar (results shown in column 2).

As with the regressions for fuel expenditures, the other coefficients in these two specifications are very similar. Hence, the following discussion focuses on the coefficients in column 1.

Examining household characteristics, the results show that all expenditure quintiles have significantly more PTX relative to the base group (EQ1) and to each other (approximately $40 for EQ2 compared to approximately $280 for EQ5). When examining the highest education level in the household, the coefficients for households with higher qualifications (bachelor's and post-graduate qualifications) are positive and significant, indicating that households with higher educational qualifications have significantly higher PTX than other households (post-secondary and below). There is no significant difference between households in rentals and homeowners.

In terms of household composition, the coefficient for coupled-only households is negative and significant indicating that these households have significantly lower PTX than the base group (single-person households). The coefficients for all the other household types are positive and significant), indicating that these households spent significantly more on public transport than one-person households. The coefficient on households with at least one retiree is negative and significant, indicating that these households spent less on PTX than those with no retirees.

In terms of location, the coefficient for Wellington households is both positive and significant, indicating that these households had significantly higher PTX (approximately $185 annually) compared to households in the Auckland region. The coefficients for households in all other regions are negative and significant indicating that households in the other regions of the country had significantly lower PTX (ranging from $90 to $150 annually) than those in the Auckland region. However, neither the distance measure coefficient nor the housing cost measure coefficient is significant. The coefficient for households with fuel expenditures is also not significant. These results indicate that, given our other controls, neither the distance to the centre, the cost of housing, nor having fuel expenditures significantly affects the level of household spending on PTX.

Table 8: Regression analysis of Public Transport Expenditures

	(1) PTX ($)	(2) PTX ($)	(3) PTX (LN)	(4) PTX (LN)	(5) PTX (SH)	(6) PTX (SH)
Petrol Price (c/l)		1.173*** (0.322)		0.0106*** (0.00126)		3.97e-06 (5.44e-06)
2009/10	10.40 (14.33)		0.189** (0.0894)		-0.000367 (0.000328)	
2012/13	36.59** (17.38)		0.370*** (0.0964)		-0.000261 (0.000341)	
2015/16	117.4*** (31.40)		0.562*** (0.0959)		0.000553 (0.000423)	
2018/19	104.3*** (26.79)		1.077*** (0.0969)		0.000170 (0.000481)	
EQ2	39.87** (17.48)	37.42** (18.13)	0.349*** (0.126)	0.317** (0.128)	0.000575 (0.000502)	0.000443 (0.000526)
EQ3	61.78*** (17.24)	56.04*** (16.46)	0.256** (0.125)	0.259** (0.124)	0.000261 (0.000387)	6.01e-05 (0.000395)
EQ4	125.3*** (22.64)	117.1*** (21.80)	0.512*** (0.137)	0.518*** (0.136)	0.000431 (0.000415)	0.000187 (0.000423)
EQ5	277.4*** (47.86)	262.1*** (45.56)	0.533*** (0.143)	0.505*** (0.141)	0.000465 (0.000565)	0.000140 (0.000559)
Secondary	0.158 (14.62)	-4.275 (14.72)	-0.0901 (0.132)	-0.108 (0.127)	0.000118 (0.000381)	6.69e-05 (0.000381)
Post-secondary	-20.99 (16.90)	-22.68 (16.83)	-0.111 (0.136)	-0.155 (0.130)	-0.000204 (0.000350)	-0.000247 (0.000351)
Bachelor	68.97** (28.42)	73.21*** (28.29)	-0.00368 (0.138)	0.0111 (0.133)	0.00125** (0.000574)	0.00125** (0.000577)
Post-grad	116.7*** (29.88)	121.6*** (29.96)	-0.0341 (0.138)	-0.0272 (0.134)	0.00148*** (0.000473)	0.00152*** (0.000476)
Public Rental	43.67 (26.58)	42.94 (26.64)	-0.142 (0.132)	-0.167 (0.130)	0.00194*** (0.000635)	0.00194*** (0.000637)
Private Rental	32.64 (20.90)	29.33 (21.02)	-0.107 (0.0709)	-0.132* (0.0731)	0.000294 (0.000312)	0.000262 (0.000315)

Any Maori	-8.592	-7.845	-0.0597	-0.0573	-7.18e-05	-6.85e-05
	(30.94)	(30.92)	(0.0852)	(0.0853)	(0.000369)	(0.000368)
Couple Only	-53.44**	-52.40**	-0.218*	-0.204*	-0.00108**	-0.00111**
	(21.14)	(20.36)	(0.118)	(0.121)	(0.000465)	(0.000449)
Coupled Parents	46.53*	48.65*	-0.0850	-0.0842	0.000256	0.000204
	(25.60)	(25.56)	(0.117)	(0.120)	(0.000541)	(0.000528)
Sole Parents	66.30**	65.25**	0.130	0.138	0.00132*	0.00124*
	(28.03)	(27.31)	(0.125)	(0.125)	(0.000679)	(0.000661)
Other one-family	73.09*	70.25*	0.0307	0.00237	0.000954	0.000861
	(41.37)	(40.99)	(0.135)	(0.138)	(0.000671)	(0.000652)
All other HH	118.8***	120.7***	-0.0604	-0.0250	0.00116*	0.00109*
	(44.91)	(43.97)	(0.140)	(0.139)	(0.000664)	(0.000649)
Retiree	-37.76**	-33.65**	-0.166	-0.137	-0.000994***	-0.000950***
	(15.72)	(15.42)	(0.109)	(0.111)	(0.000351)	(0.000347)
Canterbury	-96.35***	-97.09***	-0.364***	-0.366***	-0.00155***	-0.00157***
	(33.04)	(33.02)	(0.0975)	(0.0991)	(0.000452)	(0.000447)
North Island	-128.3***	-127.5***	-0.167*	-0.179*	-0.00228***	-0.00229***
	(21.47)	(21.40)	(0.0939)	(0.0974)	(0.000359)	(0.000360)
South Island	-140.0***	-138.6***	-0.544***	-0.549***	-0.00235***	-0.00233***
	(23.76)	(23.46)	(0.119)	(0.122)	(0.000387)	(0.000383)
Wellington	182.7***	181.5***	0.0815	0.0641	0.00257***	0.00258***
	(34.94)	(35.08)	(0.0717)	(0.0730)	(0.000525)	(0.000529)
Housing Costs	-0.00168	-0.00110	3.93e-06	7.30e-06***	-3.93e-08***	-3.35e-08***
	(0.00108)	(0.00102)	(2.48e-06)	(2.43e-06)	(1.20e-08)	(1.08e-08)
Dist to TAW (min)	-0.0479	-0.0764	0.00984**	0.00926**	-1.06e-05	-1.18e-05
	(0.808)	(0.820)	(0.00419)	(0.00428)	(9.56e-06)	(9.63e-06)
Fuel Expenditures (0/1)	-3.387		0.0583		-0.000601*	
	(17.17)		(0.0690)		(0.000316)	
Observations	16146	16146	2037	2037	16146	16146
R-squared	0.043	0.041	0.165	0.128	0.029	0.027

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

When we use the log of PTX as the dependent variable (results shown in columns 3 and 4), the coefficient for all years were significantly different from 2006/07. The coefficient on the price of petrol is positive and significant as shown in column 4, indicating that a one cent increase in the fuel price increases PTX by about 1% for those households that have PTX.

The coefficients for all quintiles are positive and significant using the logged values of PTX, increasing with each subsequent quintile. The households in the highest two expenditure quintiles spend significantly more (approximately 70% more) than those in the lower-expenditure quartiles conditional on having PTX.

Using the log of PTX as the dependent variable, the coefficients on the measures for households' educational qualifications are not significant, implying that educational qualification was not a significant factor in households' PTX conditional on them having PTX. These results indicate that the difference in the levels of PTX for households with higher educational qualifications is likely related to having PTX (given the significant coefficients shown in columns 1 and 2) and not to the amount of PTX conditional on having these expenditures. Similarly, for our household types, all of the coefficients lose their significance,[60] indicating that the main difference in the level of expenditures between the groups was due to the likelihood of having PTX and not due to the amount of PTX spent.

The coefficients for households in rentals are insignificant in the specification, indicating that housing tenure was not a significant factor in household spending on public transport during this time period.

The results related to location also change substantially compared to those shown in the first two columns. First, the coefficients for Canterbury and the rest of the South Island are the only significant coefficients at the 5% level, with households in Canterbury spending about 40% less and households on the rest of the South Island spending about 30% less than households in Auckland, conditional on having PTX. Second, the coefficient on our distance measure is significant and positive, indicating that living further from the TAW centre increases households' PTX (conditional on having PTX).

As with the results using the levels of PTX (shown in columns 1 and 2), the coefficients for the household fuel expenditures indicator and for the housing costs measure are not significant in the logged specification.

Columns 5 and 6 show the regression results using the share of total expenditures spent on public transport as the dependent variable. In this set of specifications, we find that neither the

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[60] The coefficient for couple-only households is significant at the 10% level but not at the 5% level, which is the threshold for significance in this report.

year, nor the interview month, nor the price of petrol is a significant factor in the household share spent on public transport.

The coefficients on the expenditure quartiles are also not significant, which indicates that households across the expenditure distribution spend about the same share of their budget on PTX despite spending different amounts. The coefficients for households with higher education levels (bachelor's and post-grad qualifications), however, are positive and significant, indicating that households with higher education levels allocate a larger share of their budget to public transportation than households with lower education levels. We also find that the coefficient for households in public rentals is now strongly significant and positive, indicating that these households spent significantly more of their budget on public transport than other households (either private renters or homeowners), even though the amounts they spent were similar to those spent by other households. Households with retirees, however, spent a significantly lower share of their overall budget on public transport.

In addition to spending more on public transport, households in the Wellington region also spent a larger share of their budget than households in Auckland. Moreover, households in all other regions of the country allocated a significantly smaller share of their total budget to public transport than households in Auckland. Housing costs were also significantly and negatively related to PTX share, indicating that households with higher housing costs allocated less of their total budget to public transport. For the distance measure[61] and the fuel expenditure indicator,[62] the coefficients were insignificant.

[61] However, when we used distance to the nearest city instead of distance to the nearest TAW centre, the coefficient on our distance measure was both negative and significant (results not shown). This indicates that households living further from a city spend less of their budget on public transport, which makes sense given that public transport is generally more available closer to city centres.
[62] The coefficient on the fuel expenditure indicator is significant at the 10% but not at the 5% level. We found similar results using the level and the log of fuel expenditures in place of the indicator.

5 Conclusions and next steps

In this paper, we review the literature on the distributional impacts of transport-related carbon policy and find that policy design can affect the distributional effects of the policy. Moreover, even without revenue recycling, transport policies (e.g., carbon taxes on fuels) have generally been found to be progressive even in developed countries.

We also analysed household expenditure data to find differences in transport expenditures based on different household characteristics. For example, we generally find that households with at least one retiree have different patterns in their transport expenditures than households with no retirees. Lower-income households also allocate their transport expenditures across the different transport expenditure categories differently. For example, lower-income households spent a much greater proportion of their transport expenditures on fuel than higher-income households. However, when looking at the share of total household expenditures spent on the different expenditure categories, we did not find much difference between income groups. So, while lower-expenditure households often have lower annual expenditure amounts, the overall budget shares they allocated to different transport categories were not generally significantly different from those of higher-income households, especially after controlling for other household characteristics.

For our regressions, we primarily focused on fuel expenditures and public transport expenditures as these are likely to be the two main categories affected by carbon pricing. In our full sample of households, we find that 72% of these households reported fuel expenditures, whereas only 13% reported public transport expenditures. Comparing households with public transport expenditures to the full sample, we see that households with public transport expenditures were more likely live in the Auckland or Wellington regions or live in private rentals and less likely to own their home, be in one-person or one-couple households, or have retirees.[63] Somewhat surprisingly, households with public transport expenditures were slightly more likely to have positive fuel expenditures than the full sample and had slightly higher average annual fuel expenditures. However, in our regression analysis, we found that households with and without public transport expenditures spent similar amounts on fuel, conditional on having fuel expenditures, though households with public transport expenditures allocated a significantly smaller share of their total expenditures to fuel.

Across all of our analyses, we tended to find that public transport was more likely to be used and used more intensively by households with higher incomes and higher education qualifications (bachelor's degree and above) living in more densely populated areas. Yet, we

[63] The SuperGold Card was introduced in 2008 which allows free off-peak travel for those aged 65 years or older. Hence, this would affect both the reporting likelihood and the amount of public transport expenditures for retirees.

did not find significant differences in the share of total expenditures allocated for public transport by different income groups. We did, however, find that households in public rentals allocated a larger share of their budget to public transport than other households.

When analysing fuel expenditures, we also found some consistent themes. For example, households with a post-secondary degree as the highest qualification were more likely to have fuel expenditures, more likely to spend more on fuel, and to allocate a significantly larger share of their total expenditures to fuel compared to other households.

We also found that higher housing costs and being closer to an economic centre also reduced the likelihood of households having fuel expenditures, reduced the amount households spent on fuel, and reduced the share of the household budget allocated to fuel.

Higher-income households were more likely to report fuel expenditures and tended to spend more on fuel than lower-income households. From our descriptive results, it appeared that the share of total expenditures that households allocated to fuel was similar across income groups; yet our regression analysis found that the highest-income groups allocated a significantly smaller proportion of their household budget to fuel than the lower-income groups. However, households in public rentals also allocated a significantly smaller proportion of their household budget to fuel than other households.

Given these results, it is difficult to determine if an increase in taxes on transport fuels would be regressive, proportional or progressive. Based on our descriptive statistics, a fuel tax would be expected to be proportional since, on average, the share of household expenditure spent on fuel is not significantly different across income groups. However, once we control for a variety of household characteristics, we find a significant difference between higher-income and lower-income households which indicates that a fuel tax could be regressive. Still, the progressive or regressive nature of a tax is generally determined based on averages taken across broad income groups (similar to our descriptive statistics using fuel expenditures).

We do, however, see a positive association between fuel prices, fuel expenditures, and public transport expenditures, which indicates that expenditures for both fuel and public transport would increase when fuel prices increase. More would need to be done to better understand the interactions between these in order to better determine the distributional effects of policies that would raise the carbon price. However, more sophisticated methods are needed to estimate the elasticity of demand for these across different groups.

Future analyses could also investigate the drop in households reporting fuel and public transport expenditures in 2018/19 or to better understand differences in rural and urban households, including the types of households that use diesel as opposed to petrol.

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7 Appendices

A1. Transportation Expenditure Classification

This classification system is based on one developed by Statistics New Zealand for their transportation cost index as delineated in Statistics New Zealand (2018).

- Vehicle purchasing costs
  - Purchase of second-hand motor cars
  - Purchase of new motor cars
- Fuels and lubricants
  - Petrol
  - Diesel
  - Oil, grease, lubricants for vehicles
- Registration, WOF, RUC, parking, licence fees etc
  - Vehicle relicensing fees
  - Parking fees
  - Warrant-of-fitness fees
  - Road user charges
  - Motoring organisation subscriptions
  - Driver licensing fees
  - Driving tuition
- Vehicle parts and maintenance
  - Tyres
  - Vehicle servicing
  - Cambelt repairs
  - Transmission repairs
  - Panelbeating, painting
  - Other electrical parts
  - Automotive batteries
  - Brake repairs
- Vehicle insurance
- Vehicle interest
- Public transport
  - Urban train fares
  - Short distance bus fares
  - Urban ferry fares
- Cycling
  - New bicycles, BMX bikes, mountain bikes
  - Bicycle accessories
  - Contents insurance

A2. Calculating travelling distance

To examine accessibility, we want to have an idea of how far households travel to work, education and shopping. The HES does not collect this information, so we seek to create a meaningful proxy measure based on the available data.

The HES has the meshblock of each household's dwelling. This will be the origin of the travel. Since we do not know the location of the schools, workplaces or shopping locations of household members, we assume there are two types of location that are important in determining households' accessibility. The first is the seat of the household's TA, which is also the commercial/political hub of the area. The second is the nearest 'major city'.

As noted in section 3.1, since the Auckland TA covers a large geographic area and population, we disaggregate it into 13 wards, resulting in 79 TAWs. For 'major city', we use metropolitan area (6: Auckland, Hamilton, Tauranga, Wellington, Christchurch, Dunedin) or large regional centre (11: Whangarei, Rotorua, Gisborne, Hastings, Napier, New Plymouth, Whanganui, Palmerston North, Kapiti Coast, Nelson, Invercargill) according to Statistics New Zealand's list of Functional Urban Area 2018 V1.0.0.[64]

Meshblock is the smallest geographical area in New Zealand standard geographic classification, representing approximately 30 to 60 dwellings. Meshblocks are aggregated to create higher geographies such as area units, wards, territorial authorities, district health boards, and regions. The meshblock pattern is updated annually as population changes. There were 53,596 meshblocks in New Zealand in 2020 (46,637 in 2013). A meshblock can vary in size from part of a city block to a large area of rural land. Since we do not know the exact coordinates of each household's dwelling, we assume that households travel from the centroid of their meshblock to the centroid of their destination.

The calculations take a long time (around 17 hours), and since HES meshblocks are a subset of all New Zealand meshblocks, we suggest conducting these calculations outside the data lab environment. The calculations require these data:

1. Statistics New Zealand's data on New Zealand geography and population
   a. List of all meshblocks in New Zealand and how each meshblock corresponds to its area unit, TAs, wards and regional council, available from https://www3.stats.govt.nz/digitalboundaries/annual/. Since meshblocks are aggregated to create territorial authorities and wards, we can determine TAW for each meshblock from this data set.
   b. Centroids of meshblocks, the data for MB2013 are available from https://fyi.org.nz/request/3205-request-for-the-centroid-locations-for-census-meshblocks-and-area-units?unfold=1
   c. Land area by meshblock, also available from b).
   d. Population by meshblock, available from https://datafinder.stats.govt.nz/layer/8437-population-by-meshblock-2013-census/data/
2. OpenStreetMap for New Zealand, available from http://download.geofabrik.de/australia-oceania/new-zealand.html

[64] http://aria.stats.govt.nz/aria/?&_ga=2.63069865.72130959.1647231817-229268942.1612650952#ClassificationView:uri=http://stats.govt.nz/cms/ClassificationVersion/FqTAJFlwgUdzXUbe

3. OSRM executables are available from https://github.com/christophrust/osrmtime/blob/master/README.md.

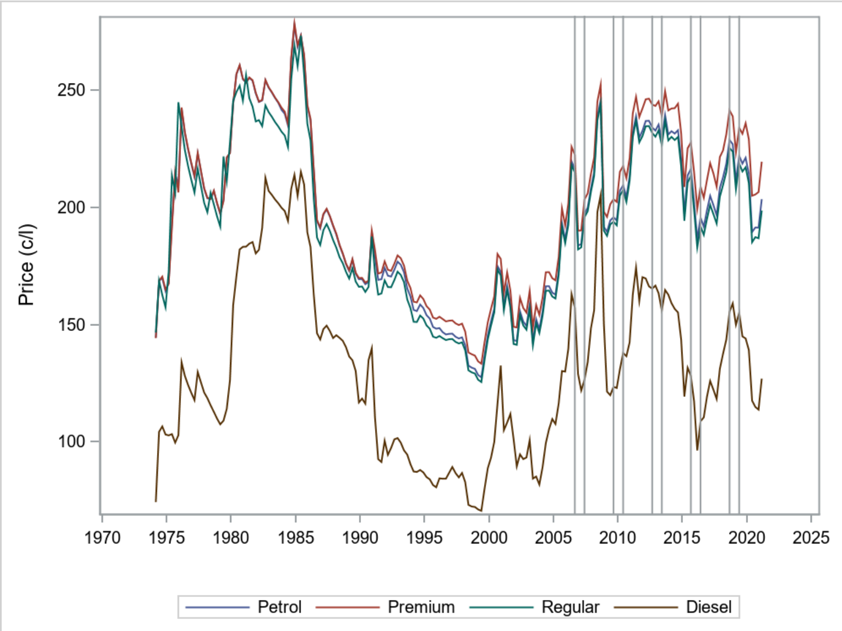
4. Osrmtime programme for Stata, also available from 3).

Meshblock is in the ‘address’ table in the HES data. In the current data archive it is based on the 2019 meshblock pattern. A concordance table[65] can be used to convert MB2019 to MB2013 and merge with the distance data. More detailed instructions and programming codes are available from the authors upon request.

[65] For example, IDI Metadata.metadata.meshblock_concordance_2020

A3. Quarterly Fuel Prices, 1975:Q1-2021:Q1

(a)



(b)

Source: Ministry of Business, Innovation and Employment