WORKING PAPER

ITLS-WP-26-09B

Should I stay or should I travel? An analysis of increasing petrol prices on travel behaviour

By
Andrea Pellegrini[a], Matthew J. Beck[a], John M. Rose[a]

[a] Institute of Transport and Logistics Studies (ITLS), The University of Sydney, Australia

May 2026

ISSN 1832-570X

INSTITUTE of TRANSPORT and LOGISTICS STUDIES

The Australian Key Centre in Transport and Logistics Management

The University of Sydney

Established under the Australian Research Council's Key Centre Program.

NUMBER: Working Paper ITLS-WP-26-09B

TITLE: Should I stay or should I travel? An analysis of increasing petrol prices on travel behaviour

ABSTRACT: This paper examines how rising petrol prices affect weekly travel behaviour, with particular attention to modal substitution and trip suppression. The analysis draws on stated responses from 808 Queensland residents, each of whom first reported their travel behaviour for the week prior to the survey and then indicated how that behaviour would change under three hypothetical petrol price scenarios set at AUD 2.50, AUD 3.00, and AUD 3.50 per litre (noting fuel prices at the pump varied between an average of AUD 2.20 and AUD 2.53 during the survey period). Weekly trip frequencies are jointly modelled for eight travel outcomes, including car travel as driver, car travel as passenger, public transport, taxi, rideshare, cycling, walking, and avoided trips. The latter category is included within the hypothetical setting to capture the extent to which increase in petrol prices may lead travellers to cancel or forgo trips altogether, rather than simply reallocate travel across modes. The empirical analysis is performed implementing a multivariate Generalised Poisson framework with dependence across travel alternatives introduced through a Gaussian copula. The results indicate that higher petrol prices substantially reduce car travel both as driver car passenger, while increasing public transport use, particularly at the higher price scenarios. However, the substitution towards public transport is only partial. A sizeable share of the adjustment instead occurs through avoided trips, suggesting that fuel price increases are more likely to suppress travel rather than simply induce a reallocation across modes. The findings further show that behavioural responses vary with socio-economic circumstances and perceived transport disadvantage, implying that the burden of higher fuel prices is unevenly distributed. Overall, the paper shows that rising petrol prices affect not only mode choice, but also the ability of individuals to maintain everyday mobility and activity participation.

KEY WORDS: ***Petrol price impacts, Travel behaviour patterns, Mobility and Accessibility, Multivariate framework***

AUTHORS: **Pellegrini, Beck, Rose**

ACKNOWLEDGEMENTS: NIL

CONTACT: INSTITUTE OF TRANSPORT AND LOGISTICS STUDIES (H04)

The Australian Key Centre in Transport and Logistics Management

The University of Sydney NSW 2006 Australia

Telephone: +612 9114 1813

E-mail: business.itlsinfo@sydney.edu.au
Internet: http://sydney.edu.au/business/itls

DATE: May 2026

INTRODUCTION

Cost-of-living pressures are increasingly shaping everyday decisions, including decisions about when, how, and even whether to travel. As argued by Beck and Greaves (2026), cost-of-living stress is cumulative and multidimensional. Pressures linked to housing, food, energy, and transport do not operate independently, but combine to affect how households manage everyday life. Within this setting, petrol prices matter not only for the direct cost of driving, but also for the additional pressure they place on already stretched household budgets. The question, therefore, is not only whether driving becomes more expensive, but whether households are able to maintain their usual levels of mobility, participation, and discretionary activity.

A growing body of work shows that transport costs need to be understood as part of broader household affordability pressure. In Australia, Vidyattama, Tanton and Nepal (2013) show that once transport costs are brought into measures of housing-related financial stress, a different picture emerges of which households are under pressure, especially families with children and households outside capital cities. Saberi et al. (2017) make a similar point for Melbourne, showing that places that appear affordable on housing costs alone may no longer look affordable once transport costs are included. In Santiago, Tiznado-Aitken et al. (2022) further show that housing and transport burdens often accumulate rather than offset one another, leaving lower-income households with a much narrower set of feasible housing and mobility choices.

This broader affordability setting helps explain why the response to higher petrol prices may extend beyond simple mode substitution. Recent evidence from Scotland reported by Fountas et al. (2025) shows that the cost-of-living crisis is associated both with changes in usual mode of travel and with reductions in the number of trips people make. Their results point to strong distributional effects, with lower-income households and other vulnerable groups more likely to change mode and to cut travel. More generally, Dabrowski et al. (2025) show that financial strain and “money anxiety” can reshape everyday decision-making in ways that go beyond narrow expenditure choices. In the travel context, this means that rising petrol prices may lead some people to drive less, some to rely more on public transport, and others to reduce discretionary activity altogether. The key point is that petrol prices may affect not only how people travel, but also whether some trips are made at all.

The existing literature on fuel prices and travel behaviour also points in this direction, although most studies have focused more on substitution than on suppressed travel. Belloc et al. (2024) find that higher gasoline prices in the United States are associated with less commuting by private motor vehicle and more commuting by public transport, walking and cycling. In a similar vein, Chen et al. (2011) show that public transport ridership responds to gasoline prices and, importantly, that the response differs between price rises and price falls. Mily et al. (2024) find that a sharp fuel price increase reduced recreational travel and trip length while encouraging movement away from petrol-dependent modes. While these studies provide evidence that fuel prices can affect both mode choice and travel intensity, much less is known about whether higher fuel prices may also induce travellers to cancel or forgo trips altogether.

The literature on transport poverty and transport disadvantage reinforces the importance of that distinction. Lucas et al. (2016) argue that transport affordability has consequences that extend well beyond mobility itself, affecting access to opportunities, social participation and broader wellbeing. Similarly, Syed and da Silveira Gorman (2025) show that housing, transportation and commuting pressures can combine to create difficult and reinforcing constraints on everyday life. Putting the latter into prospective, rising petrol prices are not only a question of vehicle operating costs, but as well they can deepen existing inequalities in people's ability to maintain routine activities, especially when the room to substitute towards other modes is limited.

Against this background, the present paper examines how rising petrol prices influence weekly travel behaviour in Queensland, with particular attention to substitution across modes and the suppression of trips altogether. The underlying premise is that higher fuel prices may reduce private vehicle use, encourage some shift towards public transport, and at the same time constrain overall mobility for those with fewer viable alternatives. Within this context, the paper thus seeks to contribute to the cost-of-living literature by treating travel not only as a household expenditure, but also as a facilitator for participation in daily life. It also contributes to the fuel-price literature by explicitly modelling avoided trips, thereby making it possible to distinguish between behavioural adjustment through mode substitution and behavioural adjustment through outright reductions in travel. As a proof of concept, the analysis draws on responses from 808 Queensland residents, each of whom reported their weekly travel behaviour for the week prior to the survey and then indicated how that behaviour would change under three hypothetical petrol price scenarios. To analyse these responses, we propose using a multivariate count data model that jointly examines eight weekly travel outcomes: car travel as driver, car travel as passenger, public transport, taxi, rideshare, cycling, walking, and avoided trips. The first seven correspond to observed travel options, whereas the avoided-trips outcome is introduced within the hypothetical petrol price scenarios to capture the extent to which a surge in fuel prices may lead individuals to cancel or forgo travel altogether. The multivariate framework also accommodates potential unobserved correlation across travel outcomes, allowing the analysis to capture the extent to which these behavioural responses are interconnected rather than independent.

The remainder of the paper proceeds as follows. The next section introduces the survey data and describes the hypothetical fuel price scenarios used in the analysis. This is followed by the model specification and estimation approach. The subsequent section presents the empirical results, focusing first on socio-economic effects, then on the behavioural impact of higher fuel prices, the role of transport disadvantage, and the correlation structure across travel outcomes. The final section discusses the broader implications of the findings and provides concluding remarks.

DATA

The empirical analysis in this paper is based on a web-based questionnaire administered in Queensland, Australia, between 16 March and 4 April 2026 via the Qualtrics platform (https://www.qualtrics.com). A total of 900 respondents were recruited across the state, of whom 82 were excluded because their completion time was below nine minutes or above 40 minutes[1], and/or because straight-lining behaviour was detected among responses to attitudinal questions. The final analytical sample therefore comprised 808 respondents.

After providing informed consent, respondents reported their state of residence and age. Eligibility was restricted to individuals residing in Queensland and aged 18 years or older. Respondents were then divided into two groups according to employment status. Employed respondents were asked whether the recent increase in petrol prices associated with the conflict in the Middle East had affected their work arrangements, with particular focus on changes in the number of days worked from home. They were also asked how they expected this pattern to evolve if fuel prices were to remain at their current level over the following 12 months. Both employed and non-employed respondents then had to state their level of support for the existing 50-cent flat fare public transport scheme (see, Queensland Government 2024a; 2024b; Rose et al., 2024) in the context of rising fuel prices and broader cost-of-living pressures, and the extent to which they believed the scheme could help households cope with increasing transport costs.

In the next section, all respondents reported the petrol price paid at their most recent refuelling, with the option of indicating zero if their vehicle was electric[2]. They also provided the number of trips made in the previous week by mode, including car as driver, car as passenger, public transport, taxi, rideshare, cycling, and walking. Respondents were subsequently asked how their weekly trip frequencies would change under three hypothetical petrol price levels, AUD 2.50, AUD 3.00, and AUD 3.50 per litre. Note that during the survey period, fuel prices in QLD ranged between an average of AUD 2.20 per litre on the 16th of March, rising to a state average higher of AUD 2.53 per litre on the 29th of March, falling to AUD 2.40 per litre on the 6th of April (AIP, 2026). An additional "avoided trips" category was included to capture trips that respondents would choose not to make under each hypothetical price scenario. Respondents were also required to indicate the activity purpose associated with the reported trips. Activity purposes included work/commuting, education (school/university), grocery or essential shopping, other shopping/errands, social activities (e.g., visiting friends or family), and personal business. In addition, respondents were asked whether they would change their activity participation if fuel prices were to be retained at current levels. Where applicable, they were then given the option to indicate which trips they would no longer make by assigning a frequency count to a separate category labelled "Trips I would no longer make (cancelled)".

The penultimate section comprised a battery of attitudinal statements specifically designed to measure perceived transport disadvantage, capturing the extent to which respondents' travel routines and access to activities are constrained by limited accessibility, inadequate transport services, affordability issues, and other related barries to mobility. The final section collected socio-economic and demographic information, including age, gender, household income, and household composition.

Sample statistics

Table 1 reports the socio-demographic characteristics of the final sample alongside benchmark statistics for Queensland (Queensland benchmark values reported in Table 1 are drawn from

[1] Survey time thresholds were calibrated on a pilot survey with 60 respondents conducted during the week prior to the main fieldwork. Feedback from the pilot was used to improve the overall flow and question clarity.
[2] Only 12 out of 808 respondents reported their primary vehicle being electric.

the 2021 ABS Census for Queensland). Overall, the sample aligns well with the state population across several key dimensions, while displaying some differences that are typical of online survey panels.

The average age of respondents is 47.6 years, closely matching the Queensland average (47.0 years). However, the age distribution is slightly skewed toward middle-aged and older individuals. Respondents aged 18–39 account for 38.4 percent of the sample, compared with 32.9 percent statewide, while those aged 40–59 are largely over-represented (35.0 percent versus 25.6 percent). Individuals aged 60 years or older also constitute a slightly greater share of the sample (26.6 percent) than in the Queensland population (22.8 percent). Females represent 54.6 percent of respondents, compared with 51 percent at the state level. Median weekly household income in the sample (AUD 1,999.50) is very close to the Queensland median (AUD 2,024.00), suggesting that the survey captures a broadly representative income profile despite differences in other socio-demographic characteristics. Full-time employment is under-represented in the sample (46.5 percent versus 56 percent), as is part-time employment (18.0 percent versus 31 percent). Around 26.1 percent of respondents report not being employed (e.g., retired, students, or unemployed but looking for job), while smaller shares are self-employed (7.1 percent) or casually employed (2.4 percent). Among employed respondents, the average number of days worked from home is 1.09, reflecting the continued persistence of hybrid work arrangements.

Table 1: Sample description

	Survey	**Queensland**
Survey timeframe		
Start date of survey	16-Mar-24	
End date of survey	4-April-26	
Sample size	808	
Age (average)	47.56	47.01
Age 18-39	38.37%	32.90%
Age 40-59	35.02%	25.60%
Age 60 or older	26.61%	22.80%
Female	54.58%	51%
Weekly household (HH) income (median)	$1,999.50	$2,024.00
Employment status		
Employed full time	46.53%	56%
Employed part time	17.95%	31%
Sel-employed	7.05%	-
Causally employed	2.35%	-
Not employed	26.11%	-
Number of days worked from home (average)	1.09	-
Type of occupation		
Managers	15.72%	-
Professionals	18.44%	-
Other professions	65.84%	-
Type of residence		
Metropolitan	59.03%	-
Rest of Queensland	40.97%	-
Number of adults in HH (average)	2.07	1.81
Presence of children in HH	36.51%	-
At least a bachelor's degree	41.09%	21.90%
Number of cars (average)	1.96	1.9
Number of bikes (average)	0.59	-

In terms of educational attainment, the sample is substantially more highly educated than the Queensland population, with 41.10 percent of respondents holding at least a bachelor's degree, relative to 21.9 percent statewide. Household composition also differs slightly from state averages. The mean number of adults per household is 2.07, as opposed to 1.81 in Queensland, and 36.5 percent of respondents report the presence of children in the household. With respect to residential location, 59.0 percent of survey participants live in metropolitan areas, whilst the remaining 41.0 percent reside in the rest of Queensland, allowing the analysis to capture both urban and non-urban travel contexts. Car ownership in the sample is closely aligned with population levels, with an average of 1.96 cars per household, compared with approximately 1.9 statewide. Respondents also report an average of 0.59 bicycles per household, indicating some degree of exposure to active transport options.

Travel patterns under increasing fuel prices

Table 2 displays the average number of weekly trip counts by mode under the status quo (which refers to the trips made the week preceding survey enrolment), together with those reported under three hypothetical petrol price levels: AUD 2.50, AUD 3.00, and AUD 3.50 per litre. For each scenario, respondents reallocated trips across travel modes and avoided trips, with the latter option embedded within the survey explicitly to capture whether higher fuel prices may lead some individuals to forego travel altogether rather than substitute toward an alternative mode.

At the current petrol prices respondents reported paying at their most recent refuelling, the sample made an average of 10.95 trips per week, including 5.77 as car drivers and 1.42 as car passengers, confirming the continued dominance of private cars in everyday mobility. Public transport use averages 1.43 trips per week, while walking (1.78) and cycling (0.22) play a secondary but non-negligible role. Taxi and rideshare use is limited, together accounting for fewer than 0.35 trips per week. As petrol prices increase, a clear and progressive adjustment in travel behaviour emerges. Car travel declines steadily across all hypothetical price levels. Trips made as car driver fall from 5.77 under the status quo to 4.97 at AUD 2.50, 4.25 at AUD 3.00, and 3.63 at AUD 3.50 per litre. Car passenger trips exhibit a similar pattern, decreasing from 1.42 to 0.88 trips per week at the highest price level. These reductions indicate a strong sensitivity of car-based travel to fuel costs. At the same time, public transport use increases monotonically with fuel prices, rising from 1.43 weekly trips under current prices to 2.12, 2.61, and 2.87 trips at AUD 2.50, AUD 3.00, and AUD 3.50, respectively. This pattern suggests that higher petrol prices encourage a degree of substitution away from private vehicle use toward public transport. Active modes display less pronounced responses with cycling increasing modestly at higher prices, while walking remains broadly stable across the three scenarios. Taxi and rideshare use remain marginal throughout and do not display a clear upward trend, suggesting that these modes do not represent a widespread alternative response to rising fuel costs in this context. Instead, a notable result is the emergence and growth of avoided trips, which are observed only in the hypothetical price scenarios. Avoided trips increase from 0.48 per week at AUD 2.50 to 0.90 at AUD 3.00 and 1.30 at AUD 3.50 per litre. This pattern indicates that a share of the behavioural response to higher fuel prices involves the suppression of travel demand rather than simple modal substitution.

Table 2: Average number of weekly trip counts by mode

Petrol prices	Car as driver	Car as passenger	Public transport	Taxi	Rideshare	Cycling	Walking	Avoided trips
Status quo	5.77	1.42	1.43	0.27	0.06	0.22	1.78	-
AUD 2.50	4.97	1.21	2.12	0.20	0.09	0.22	1.67	0.48
AUD 3.00	4.25	1.02	2.61	0.19	0.08	0.28	1.61	0.90
AUD 3.50	3.63	0.88	2.87	0.17	0.09	0.30	1.71	1.30

In summary, the average values in Table 2 show that rising petrol prices seems to lead to a combination of reduced car use, increased reliance on public transport, and an increasing propensity to forgo travel altogether. While some substitution toward lower-cost modes occurs, the growing number of avoided trips suggests that higher fuel prices may also negatively impact overall mobility and activity participation. Figure 1, derived from the values in Table 2, illustrates how the relative composition of weekly trips changes as petrol prices increase. Rather than showing the total number of trips made, the chart presents the proportional share of each travel mode within overall travel activity under each pricing scenario. It clearly reveals the diminishing use of the car, and the strong growth in avoided trips.

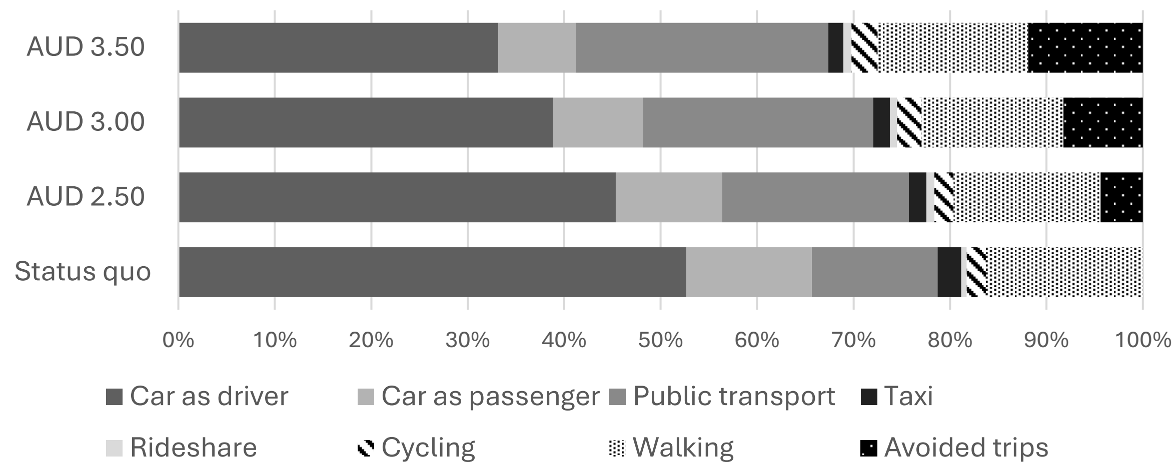

Figure 1: Trip Making by Mode as a Proportion of Status Quo Trips

The transport disadvantage composite index

In addition to socio-economic and travel-related information, the survey collected attitudinal responses on respondents' perceived ease or difficulty in dealing with a range of transport-related issues. Perceived transport disadvantage was operationalised using a composite index constructed from a battery of 18 attitudinal items originally proposed by Currie and Delbosc (2010) (see, also, Currie et al., 2010; Ma et al., 2016; Xi et al., 2025). The items capture respondents' self-reported ease or difficulty in dealing with a range of transport-related problems. Specifically, the items span difficulties associated with public transport service availability, general mobility constraints, personal vulnerability or impairment, and reliance on others for mobility.

A principal components analysis (PCA) was applied to the original set of 18 items to identify the latent structure underlying perceived transport disadvantage and to derive domain-specific components. Consistent with Currie and Delbosc (2010), two items exhibiting weak loadings or substantial cross-loadings across multiple components were excluded prior to final score construction. In the present application, two additional items, *finding the time to travel* and *covering the costs of transpor*t were also removed due to unstable loading behaviour. The *varimax* rotated component matrix for the remaining 14 items (Table 3) reveals a clear four-component solution[3]. The first component captures transit disadvantage, loading strongly on items related to night-time and weekend availability, service frequency, and the ability to make connections. The second component reflects broader transport disadvantage, characterised by difficulty getting around reliably, travelling quickly, finding suitable transport, and travelling when desired. The third component corresponds to vulnerability or impairment, encompassing safety concerns, physical accessibility, wayfinding, and the need for assistance. The fourth component captures reliance on others, with high loadings on having to depend on others for transport and on finding assistance when transport is available. Overall model adequacy was assessed using the root mean square residual (RMSR), whose estimated value of 0.06 suggested an acceptable level of correspondence between observed and reproduced item correlations.

Table 3: PCA results

Factor group name	**Component feature of transport disadvantage: difficulty with…**	RC1	RC2	RC3	RC4
Transit disadvantage	Buses/trains/trams being available at night	0.78			
	Buses/trains/trams being available at weekends	0.75			
	Buses/trains/trams operating frequently	0.72			
	Being able to make bus/train/tram connections	0.83			
Transport disadvantage	Being able to get around reliably		0.82		
	Getting to places quickly		0.85		
	Finding transport so you can travel		0.82		
	Being able to travel when you want to		0.72		
Vulnerable/impaired	Feeling safe from theft/attack when travelling on your own			0.48	
	Needing help to get around on your own			0.77	
	Being able to understand where to go			0.70	
	Being able to physically get onto/off buses/trains/trams			0.64	
Rely on others	Finding someone to provide assistance when transport is available				0.60
	Having to rely on others for transport				0.81

Component scores were computed for each retained domain and subsequently combined to form a Transport Disadvantage Composite (TDC) index. Rather than treating the extracted dimensions as reflective indicators of a single latent construct, the TDC index was specified as

[3] The descriptive statistics of the identified 14 items are reported in the Web Appendix.

a formative composite, whereby each domain contributes additively to overall transport disadvantage (examples of similar index constructions include Church et al., 2000; Martens, 2016; Xiao et al., 2018; Saadi and Martens, 2025). This approach is consistent with the measurement literature on index construction using formative indicators, which emphasises that distinct dimensions jointly define the construct rather than serving as interchangeable manifestations of an underlying latent trait (Diamantopoulos and Winklhofer, 2001; Jarvis et al., 2003).

To construct the TDC index, we implemented a variance-based weighting scheme following the weighted-average method (OECD and European Commission Joint Research Centre, 2008, p. 89), consisting of weighting domain scores by their proportion of explained variance obtained from the principal component analysis PCA. By doing so, we assigned greater influence to domains that account for a larger share of the common variance in perceived transport difficulty, while preserving the multidimensional structure identified in the data. As reported in Table 4, the last two components, *Vulnerable/impaired* and *Rely on others*, account for the majority of the explained variance, whereas the remaining components capture more specific, yet substantively meaningful, aspects of transport disadvantage. Weighting domains by their explained variance therefore reflects their relative contribution to the empirical structure of perceived transport difficulty, rather than imposing equal importance across dimensions.

Conceptually, this formulation reflects the view that transport disadvantage arises through the accumulation of distinct constraints, rather than as the manifestation of a set of underlying latent traits. Methodologically, specifying the TDC index as a formative composite yields a summary measure that can be entered directly into the model specification as an observed covariate, rather than via a less parsimonious latent specification (Rose et al., 2023). This results in an ease interpretation of the estimated effects while retaining the richness of the underlying dimensions captured by the original attitudinal measures.

Table 4: Proportion of variance explained

Variance	RC1	RC2	RC3	RC4
Proportion Explain	0.24	0.13	0.30	0.33
Cumulative Proportion	0.24	0.37	0.67	1

METHODOLOGY

The empirical analysis models weekly travel patterns using a multivariate Generalized Poisson distribution of the Consul–Jain Type I form framework (Consul and Jain, 1973; Consul and Shoukri, 1984; Wang and Famoye, 1997). In contrast to standard univariate count models, this specification accommodates both over-dispersion, where variability exceeds the mean, and under-dispersion, where variability is lower than the mean. In addition to flexible marginal distributions, the model explicitly accounts for unobserved dependence across outcomes. Such dependence is introduced through a Gaussian copula, which separates the specification of each alternative's marginal count distribution from the correlation structure linking the alternatives. This structure allows each travel outcome to be modelled independently while capturing cross-alternative correlation arising from shared unobserved factors, such as individual travel needs, constraints, or preferences.

Let y_{nj} denote the observed weekly count for individual n and alternative j, with $n = 1,\dots,N$ and $j = 1,\dots,J$, where each alternative corresponds to one of the travel modes reported in Table 2, namely car travel as driver, car travel as passenger, public transport, taxi, rideshare, cycling, walking, and avoided trips. The latter is treated as a distinct outcome capturing suppressed travel demand under higher fuel prices. Conditional on covariates, each marginal outcome is assumed to follow a Generalized Poisson distribution with probability mass function

$P(Y = y) = \frac{\lambda(\lambda + \phi\, y)^{(y-1)} e^{-(\lambda + \phi\, y)[\ \ ]}}{y!}$, y = 0, 1, 2, …	(1)

where $\lambda > 0$, $\phi < 1$, and $\lambda + \phi\, y > 0$ for all admissible y. The parameter restrictions as described ensure non-negativity of probabilities over the support.

Under this parameterization, λ is a scale parameter and ϕ governs departures from equi-dispersion. The corresponding mean and variance are given by

$E[Y] = \frac{\lambda}{(1-\phi)}$, $Var(Y) = \frac{\lambda}{(1 - \phi)^3} = \frac{E[Y]}{(1 - \phi)^2}$,	(2)

such that $\phi > 0$ implies over-dispersion, $\phi < 0$ entails under-dispersion[4], and $\phi = 0$ yields the standard Poisson model as a special case. For , $\phi < 0$ the support is implicitly truncated to ensure $\lambda + \phi\, y > 0$.

Rather than parameterizing the generalized Poisson directly in terms of λ, the model is reparameterized using the conditional mean μ, where $\mu = \frac{\lambda}{1-\phi}$, so as to explicitly recognize the potential presence of over-or-under dispersion in the data. To allow both the mean and the degree of dispersion to vary across individuals and alternatives, the conditional mean μ_{nj} and the dispersion parameter ϕ_{nj} can be specified as follows:

$\mu_{nj} = exp(x'_{nj}\beta_j)$, $\phi_{nj} = 1 - exp(-\, l'_{nj}\gamma_j)$,	(3)

where x_{nj} and l_{nj} are vectors of explanatory variables (e.g., age, household vehicle fleet, weekly household income, etc.) entering the mean and dispersion equations, respectively, and β and γ are the corresponding alternative specific vectors of parameters to be estimated. The functional form adopted for the dispersion parameter, $\phi_{nj} = 1 - exp(-\, l'_{nj}\gamma_j)$, ensures that the condition $\phi < 1$ is satisfied during estimation. The corresponding generalized Poisson scale parameter is therefore

[4] When $\phi < 0$, the support of the distribution is implicitly truncated to values of y satisfying $\lambda + \phi y > 0$, thus ensuring the probability mass function is well defined.

$\lambda_{nj} = \mu_{nj}(1 - \phi_{nj}),$	(4)

which preserves the familiar log-link structure for the mean while allowing dispersion to vary flexibly across observations.

The marginal cumulative distribution function, $F_j(y_{nj}|\mu_{nj}, \phi_{nj})$, is obtained from the generalized Poisson probability as

$F_j(y_{nj}|\mu_{nj}, \phi_{nj}) = \sum_{k=0}^{y_{nj}} f(k \mid \lambda_{nj}, \phi_{nj}), \lambda_{nj} = \mu_{nj}(1 - \phi_{nj}),$	(5)

where $f(\cdot)$ denotes the generalized Poisson probability mass function.

Residual dependence across alternatives is introduced using a Gaussian copula (Masarotto and Varin, 2017). For discrete outcomes, the likelihood contribution is expressed in terms of Gaussian rectangle probabilities. Each pairwise likelihood contribution is evaluated using differences of bivariate normal cumulative distribution functions. Specifically, lower and upper probability bounds are defined as

$u_{nj}^{L} = F_j(y_{nj} - 1 \,|\mu_{nj}, \phi_{nj}),$ $u_{nj}^{U} = F_j(y_{nj}|\mu_{nj}, \phi_{nj}),$	(6)

which are mapped to the latent Gaussian scale via

$z_{nj}^{L} = \Phi^{-1}(u_{nj}^{L})\,,$ $z_{nj}^{U} = \Phi^{-1}(u_{nj}^{U}),$	(7)

where $\Phi^{-1}(\cdot)$ denotes the inverse standard normal cumulative distribution function.

Let $W_n = (W_{n1}, \ldots, W_{nJ})'$ follow a multivariate normal distribution with mean zero, and correlation matrix R, $W_n \sim MVN(0, R)$, where R is a $J \times J$ correlation matrix. The observed discrete outcome y_{nj} corresponds to the latent event such as

$z_{nj}^{L} < W_{nj} \leq z_{nj}^{U}.$	(8)

Under this construction, the joint probability of any multivariate count realization is represented by a Gaussian rectangle probability. The correlation matrix R is parameterized via an unrestricted vector of dependence parameters. A lower-triangular matrix with unit diagonal elements is first constructed, yielding a symmetric positive-definite matrix that is subsequently standardised to produce a valid correlation matrix. Because the full *J-dimensional* likelihood of a discrete Gaussian-copula model can be computationally demanding, estimation is conducted using pairwise composite maximum likelihood (PCML) (Lindsay, 1988;

Apanasovich et al., 2008; Bhat et al., 2010). For each unordered pair of alternatives, the likelihood contribution is given by a bivariate Gaussian rectangle probability. Let D denote the set of unordered alternative pairs, $D = \{(a, b): 1 \le a < b \le J\}$. The pairwise composite log-likelihood is then

$\ell_C(\theta) = \sum_{n=1}^{N} \sum_{(a,b)\in D} log\, p_{nab}(\theta).$	(9)

For each unordered pair of alternatives $(a, b) \in D$, define the corresponding bivariate latent vector as $W_{nab} = (W_{na}, W_{nb})' \sim MVN(0, R_{ab})$, and R_{ab} denotes the 2×2 correlation matrix associated with alternatives a and b. The pairwise likelihood contribution is then given by

$p_{nab} = P(z_{na}^{L} < W_{na} \le z_{na}^{U}, z_{nb}^{L} < W_{nb} \le z_{nb}^{U}) ,$	(10)

for each unordered pair $(a, b) \in D$, where the pair-specific correlation matrix is defined as

$R_{ab} = \begin{bmatrix} 1 & \rho_{ab} \\ \rho_{ab} & 1 \end{bmatrix}.$	(11)

Lastly, the PCML estimator is obtained by maximizing the following expression

$\hat{\theta} = \arg\max \ell_C(\theta).$	(12)

Because the objective function is a composite rather than a full likelihood, statistical inference is based on the Godambe sandwich estimator (Godambe, 1960). Standard errors for the implied pairwise correlations are obtained via the delta method, using the numerical Jacobian mapping the unrestricted dependence parameters to the off-diagonal elements of the correlation matrix (Zhao and Joe, 2005).

RESULTS

A wide range of alternative specifications was tested, involving different combinations of explanatory variables, before identifying the formulation that provided the best fit to the data. Table 6 reports the corresponding parameter estimates. For ease of interpretation, the table is organised into four main blocks. The first block reports the alternative-specific constants and dispersion parameters, followed by the second block which shows the coefficients associated with respondents' socio-economic characteristics. The third block presents the coefficients on the three dummy variables used to capture the effect of the hypothetical petrol price scenarios on weekly travel behaviour, whereas the final block outlines those coefficients associated with the TDC index and its interactions. In what follows, we first discuss the goodness-of-fit measures, after which the attention is placed on illustrating the estimation results obtained from the estimation of the model specification described in the previous section.

From Table 5, a substantial improvement in model fit is observed once covariates are introduced, with the composite log-likelihood improving from −727,214.523 at the initial values to −200,307.112 at convergence. The corrected composite-likelihood information criteria also support the preferred specification, with the Composite Likelihood Akaike Information Criterion (CLAIC) equal to 402,240.357 and the Composite Likelihood Bayesian Information Criterion (CLBIC) equal to 407,184.502. In estimation terms, the sample comprises 3,232 scenario-specific observations, corresponding to the 808 respondents reporting travel behaviour under four conditions: the status quo and three hypothetical fuel price scenarios. For each observation, the model jointly explains the weekly counts associated with the eight travel outcomes considered in Table 2.

Table 5: Goodness of fit measures

Initial log-likelihood[5]	-727,214.523
Log-likelihood at convergence	-200,307.112
Number of respondents	808
Respondent day observations	3232
Number of parameters estimates	132
CLAIC	402240.357
CLBIC	407184.502

Baseline constants and dispersion

The alternative-specific constants reveal substantial differences in baseline participation across the eight outcomes, and their ordering closely mirrors the descriptive patterns reported in Table 2. Car travel as driver has by far the largest positive constant, confirming that, *all else being equal*, driving remains the dominant travel mode in the sample with a baseline expected frequency of approximately 6.93 weekly trips. Walking is the only other alternative with a positive constant, with an estimate of 0.632, corresponding to roughly 1.88 weekly trips. By contrast, the remaining alternatives are characterised by negative constants, indicating much lower baseline propensities. Public transport, taxi, rideshare, and cycling all exhibit comparatively low expected counts, while avoided trips also has a negative constant, consistent with the fact that trip suppression is not a dominant behaviour in the baseline setting. These findings reinforce the centrality of the private car in everyday mobility, with driving clearly emerging as the primary modal form of travel, followed by walking. Taxi, rideshare, and cycling show comparatively lower usage, whereas public transport starts from a relatively low baseline level, which is consistent with the Queensland context and the continuing dominance of private vehicle travel in daily activity participation (Rose et al., 2025). The constant for avoided trips should be interpreted somewhat differently from the mode-specific constants, insofar as it captures the baseline tendency to forgo travel once the hypothetical fuel-price

[5] It should be noted that the model is estimated using pairwise composite maximum likelihood, meaning that the objective function is constructed from the sum of all bivariate pairwise contributions, rather than from a full multivariate likelihood. With eight dependent variables, the composite criterion therefore includes 28 bivariate log-probability terms per observation. As such, the resulting composite log-likelihood should not be interpreted as numerically equivalent to the log-likelihood that would arise under a full-information multivariate likelihood.

scenarios and other covariates are introduced, rather than a directly observed status quo travel outcome.

The estimated dispersion parameters are positive and highly significant for all eight alternatives, indicating that the variance in weekly counts exceeds the corresponding conditional mean throughout. This provides empirical evidence for the use of the Generalised Poisson specification over a standard Poisson model. Over-dispersion appears particularly pronounced for public transport, cycling, and avoided trips, where the implied dispersion parameters are around 0.73 or higher. This suggests substantial unobserved heterogeneity in the intensity with which respondents use these alternatives, or in the degree at which they respond to higher fuel prices by suppressing travel altogether.

Socio-economic variables

The estimated socio-economic coefficients reveal several interesting patterns in weekly travel behaviour. Female respondents are found to drive less, cycle less, and walk less, but are more likely to travel as car passengers and to report avoided trips. The positive passenger effect is particularly pronounced, with the estimated coefficient implying an increase of around 64 per cent in expected car-passenger trips. These results suggest a lower propensity among women to undertake independent motorised or active travel, alongside a greater tendency to rely on being driven by others and, to a lesser degree, to suppress travel under higher fuel prices. Age also plays an important role in shaping travel patterns. Respondents aged 18–39 undertake fewer trips as drivers and fewer walking trips, but are more likely to travel as car passengers, use public transport, take taxis, and use rideshare. This pattern points to a lower reliance on self-driving and greater engagement with alternative travel modes among younger adults. By contrast, respondents aged 60 years and over are less likely to use rideshare and cycling, and are also less likely to cancel trips in response to higher fuel prices. The latter result may reflect a greater concentration of travel on essential or less discretionary activities among older individuals.

Employment status and occupation also matter. Full-time employment is associated with more driving and substantially greater public transport use, while reducing avoided trips. This pattern likely reflects the stronger mandatory travel requirements faced by full-time workers. Part-time employment is positively associated with public transport use, cycling, and walking, consistent with a more flexible travel profile and, perhaps, a greater concentration of shorter-distance or local trips. Occupational status shows similarly differentiated effects. Managers are more likely to use public transport, taxis, and cycling, but are less likely to report avoided trips under the hypothetical fuel price scenarios. Professionals, by contrast, make fewer trips as car passengers but more trips by public transport. Working from home also has a clear effect on travel behaviour. A greater number of days worked from home is associated with less driving, but with more taxi and rideshare use, as well as more walking. In the latter case, it is plausible that remote work arrangements are associated with greater participation in local and short-distance activities. Public transport, by contrast, appears largely unaffected by working from home, given the only marginal significance of the associated coefficient.

Household structure and income further shape mobility patterns. Households with more adults undertake more car-passenger trips but fewer walking trips, while households with children record more driving trips. Further, low-income households, defined as those with weekly household income below $999, drive substantially less, with the coefficient implying roughly 39 per cent fewer driver trips. By contrast, high-income households, defined as those with weekly household income above $3,000, drive more, travel more frequently as passengers, and are also more likely to use taxis. In percentage terms, the estimated coefficient for car-passenger travel implies an increase of around 73 per cent in expected passenger trips among high-income households. Overall, these results suggest that higher-income households maintain greater overall mobility, whereas lower-income households appear more constrained in car-based travel.

Having at least a bachelor's degree is positively associated with public transport use, with weaker positive effects for rideshare and avoided trips. This is likely to capture the fact that higher public transport use is often observed among more highly educated individuals in urban labour markets. Finally, residential context and household vehicle composition also influence weekly trip participation. Metropolitan residents tend to drive less, but are more likely to use public transport, cycle, walk, and, to a lesser extent, use taxis. This is consistent with the greater availability of non-car travel options in metropolitan areas. Car ownership exerts a negative effect on public transport use, suggesting that larger household vehicle fleets reduce reliance on transit. The opposite pattern is observed for bike ownership in the walking equation, where a greater number of bicycles in the household is associated with more walking trips. This may indicate that households with stronger non-car mobility orientations are also more likely to combine walking with other forms of active travel.

Hypothetical fuel price scenarios

The three scenario dummies, AUD 2.50, AUD 3.00 and AUD 3.50 per litre, capture how weekly travel changes as petrol prices rise relative to the status quo. The estimated effects are generally monotonic, with behavioural adjustments becoming stronger as prices increase. This is especially clear for driving, where the estimated coefficients are -0.224 at AUD 2.50, -0.454 at AUD 3.00, and -0.699 at AUD 3.50 per litre, all statistically significant. In percentage terms, these correspond to reductions of around 20, 37 and 50 percent in expected driving trips, respectively. Car travel as passenger follows the same pattern, with estimated reductions of roughly 35, 48 and 57 percent across the three price scenarios. Public transport moves in the opposite direction. The coefficient at AUD 2.50 per litre is small and not statistically different from zero, but the estimated effects become positive and significant at AUD 3.00 and AUD 3.50 per litre. These imply increases of approximately 25 and 31 percent in expected public transport trips, respectively. This suggests that public transport begins to serve as a substitute for private vehicle travel once petrol prices reach sufficiently high levels. Taxi and walking both show negative responses to the hypothetical price scenarios, although the pattern is more moderate than for car travel. Taxi use declines significantly at AUD 3.00 and AUD 3.50 per litre, while walking falls by around 17 to 21 percent across the three scenarios. This suggests that rising petrol prices do not simply shift demand toward all non-car modes. Rather, the main substitution appears to occur toward public transport, while some activities are instead foregone altogether. This latter point is most evident in the avoided-trips equation. The coefficients are positive and increasing in magnitude across all three fuel price scenarios: 0.333 at AUD 2.50, 1.103 at AUD 3.00, and 1.488 at AUD 3.50 per litre. The effects at AUD 3.00 and AUD 3.50 per litre are particularly large, corresponding to increases of around 201 percent and 343 percent, respectively, in the expected number of avoided trips. These results indicate that higher petrol prices do not simply trigger a reallocation of the travel budget across modes but also suppress mobility directly by inducing respondents to cancel or forgo trips altogether.

Transport Disadvantage Composite index

The TDC index is employed to capture the impact of accessibility and mobility barriers on travel patterns. The interpretation of the associated estimated coefficients requires some care in that the underlying attitudinal scale runs from very easy to very difficult, implying that higher values of the index indicate greater perceived transport disadvantage. For car travel as driver, the coefficient on the TDC index is negative and statistically significant, and hence we can conclude that greater perceived transport disadvantage is associated with a reduction in driving. The same pattern is much stronger for public transport and walking, with estimated reductions of roughly 45 percent in expected public transport trips and 35 percent in expected walking trips for a one-unit increase in the index. These results suggest that transport disadvantage is not simply a matter of reduced car access, but it is also associated with lower participation in modes that often function as substitutes, particularly public transport and walking. The positive coefficient in the car-passenger equation is weaker and only marginally significant, but it is directionally consistent with the idea that individuals facing greater transport disadvantage may rely somewhat more on others for travelling. This interpretation is also aligned with the construction of the index itself, which includes reliance-related dimensions. Two interaction terms further qualify these results. In the public transport equation, the interaction between the TDC index and higher income households is positive and statistically significant. This suggests that the negative association between transport disadvantage and public transport use is attenuated among higher-income respondents. In other words, greater financial resources appear to alleviate part of the adverse effect of transport disadvantage on transit use. A similar pattern emerges in the walking equation, where the interaction is also positive and significant, indicating that high-income households are better able to maintain walking participation even when perceived transport difficulty increases. In the avoided-trips equation, the interaction is between the TDC index and the highest petrol price scenario. Although being marginally statistically significant, the estimated parameter suggests that the mobility-suppressing effect of the AUD 3.50 per litre scenario may be somewhat larger for those experiencing greater transport disadvantage.

To summarize, the TDC results corroborates the idea that transport disadvantage operates as a broad mobility constraint rather than a mode-specific inconvenience. Higher disadvantage is associated with lower use of public transport and walking in particular, and the positive income interactions indicate that economic resources can partly offset these constraints. The broader implication is that fuel price increases may have especially uneven effects when coupled with pre-existing disadvantage in the transport system.

Table 6: Model results

	Car as a driver		Car as passenger		Public transport		Taxi		Ridepooling		Bicycle		Walking		Avoided trips	
Variable	Par.	T-ratio	Par.	T-ratio	Par.	T-ratio	Par.	T-ratio	Par.	T-ratio	Par.	T-ratio	Par.	T-ratio	Par.	T-ratio
Intercept	1.936	34.16	-0.408	-3.99	-0.647	-5.28	-2.133	-10.64	-2.889	-12.21	-1.658	-7.34	0.632	5.80	-1.089	-7.40
Dispersion	0.966	56.36	0.898	34.65	1.326	57.46	1.103	14.52	1.207	10.04	1.337	19.02	1.124	51.39	1.316	30.06
Female (1/0)	-0.126	-3.10	0.496	7.19	-0.083	-1.17	-	-	-0.235	-1.24	-0.640	-4.34	-0.184	-2.78	0.212	2.23
Age 18-39 (1/0)	-0.118	-2.63	0.146	2.17	0.411	5.70	0.864	6.69	0.584	2.96	0.328	2.11	-0.189	-2.94	0.143	1.34
Age 60 or older (1/0)	-	-	-	-	-	-	-	-	-0.415	-1.62	-0.706	-2.90	-	-	-0.237	-1.75
Full time (1/0)	0.198	3.36	-	-	0.532	5.25	-	-	-	-	0.190	1.05	-	-	-0.263	-2.09
Part time (1/0)	0.100	1.61	0.203	2.60	0.695	6.57	-	-	-	-	0.579	2.65	0.264	3.34	-0.391	-2.66
Managers (1/0)	0.060	1.13	-	-	0.562	5.67	0.815	5.80	0.380	1.77	0.605	3.94	-	-	-0.408	-2.66
Professionals (1/0)	-	-	-0.316	-3.43	0.282	2.79	-	-	-	-	-	-	-	-	-	-
Days worked from Home	-0.109	-7.05	-	-	0.031	1.54	0.128	3.23	0.318	8.82	0.064	1.37	0.127	6.79	-	-
# of Adults within the HH	-	-	0.198	6.47			-	-	-	-	-	-	-0.075	-2.10	-	-
Presence of children (1/0)	0.245	5.38	-	-	-0.101	-1.43	-	-	-	-	-	-	-	-	0.120	1.13
Weekly HH income < AUD 1,000	-0.497	-8.25	0.107	1.27			-	-	-	-	-	-	-	-	-0.252	-1.97
Weekly HH income >=AUD 3,000	0.193	4.04	0.549	7.18			0.254	1.93	-	-	-	-	-	-	-	-
Metropolitan resident (1/0)	-0.159	-3.81	-	-	0.695	9.00	0.223	1.73	-	-	0.365	2.42	0.135	2.08	-0.159	-1.67
At least a bachelor's degree (1/0)	-	-	-	-	0.220	2.98	-	-	0.254	1.57	-	-	-	-	0.166	1.68
# of cars within the HH	-	-	-	-	-0.056	-2.40	-	-	-	-	-	-	-	-	-	-
# of bikes within the HH	-	-	-	-			-	-	-	-	-	-	0.109	5.61	-	-
Petrol at $2.50	-0.224	-4.62	-0.435	-5.36	0.058	0.66	-0.250	-1.48	-	-	-	-	-0.188	-2.26	0.333	2.35
Petrol at $3.00	-0.454	-8.53	-0.653	-7.55	0.220	2.54	-0.377	-2.17	-	-	-	-	-0.239	-2.85	1.103	11.65
Petrol at $3.50	-0.699	-11.88	-0.834	-9.10	0.267	3.06	-0.454	-2.61	-	-	-	-	-0.215	-2.53	1.488	17.79
TDC index	-0.083	-2.14	0.098	1.63	-0.602	-6.95	-	-	-	-	-	-	-0.433	-5.82	-	-
TDC index × Weekly HH income >=AUD 3,000	-	-	-	-	0.605	4.42	-	-	-	-	-	-	0.455	3.37	-	-
TDC index × Petrol at $3.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.155	1.22

Correlation effects

The estimated correlation matrix reveals a rich pattern of residual dependence across travel outcomes, confirming the value of the multivariate specification proposed in this study (Table 7). The strongest negative correlation is observed between car travel as driver and public transport, indicating that, after controlling for observed covariates, unobserved factors that increase driving are associated with lower use of public transport, and vice versa. Smaller but still statistically significant negative correlations are also present between driving and taxi, driving and rideshare, and driving and walking. This pattern suggests that car driving competes not only with public transport but also with a broader portfolio of alternative mobility options. Car travel as passenger, on the other hand, displays a different set of relationships. It is positively correlated with taxi rideshare, cycling, and more weakly with walking. These findings suggest that some individuals are generally more mobile across a range of non-driving options, or that there are unobserved household and lifestyle factors that jointly increase reliance on being driven and on other alternatives to self-driving. The negative correlation between car passenger and public transport is comparatively smaller but still indicates a degree of substitution between these two modes.

The strongest positive correlations are concentrated among taxi, rideshare and cycling. Taxi and rideshare are very strongly related, which is unsurprising given the functional similarity between these services. Both are also found to be positively correlated with cycling. Public transport is positively correlated with taxi, rideshare, cycling and walking. Walking is positively correlated with most alternatives apart from driving and avoided trips. In particular, it is positively related to public transport, taxi rideshare, and cycling. This is consistent with walking functioning as a connecting or supportive mode within broader travel patterns. The negative correlation between walking and driving again reinforces the idea that reliance on the private car tends to rule out participation in other forms of mobility.

The negative and statistically significant correlation parameter between avoided trips and public transportation suggest that unobserved factors linked to greater transit use are associated with a lower propensity to cancel travel. One possible explanation for the negative relationship between avoided trips and public transport use is that individuals who already utilise public transport are more likely to find this mode to be accessible and convenient. Conversely, individuals with limited access to, or lower perceived convenience of, public transport may have fewer feasible alternatives available and therefore may be more inclined to avoid or suppress travel altogether. By contrast, avoided trips are positively correlated with rideshare and cycling, although these effects are modest. Correlations with driving, car passenger travel, taxi and walking are not statistically different from zero. This pattern indicates that trip suppression reflects, at least in part, a distinct behavioural response rather than simply a modal shift from one alternative to another. While some substitution towards public transport is evident in the mean effects, the residual correlation results suggest that the tendency to avoid trips altogether is only weakly connected to most other travel modes and therefore captures an additional dimension of behavioural adjustment to rising fuel prices.

Table 7: Correlation parameters and their t-ratio values

	Car as driver	Car as passenger	Public transport	Taxi	Ridepooling	Bicycle	Walking	Avoided trips
Car as driver	1							
Car as passenger	-0.055	1						
Public transport	-0.363	-0.087	1					
Taxi	-0.127	0.415	0.241	1				
Ridepooling	-0.108	0.338	0.225	0.671	1			
Bicycle	-0.048	0.187	0.09	0.454	0.603	1		
Walking	-0.145	0.048	0.176	0.143	0.158	0.244	1	
Avoided trips	-0.012	-0.017	-0.159	0.013	0.151	0.143	-0.007	1

T-ratios

	Car as driver	Car as passenger	Public transport	Taxi	Ridepooling	Bicycle	Walking	Avoided trips
Car as driver								
Car as passenger	-2.60							
Public transport	-21.15	-3.81						
Taxi	-4.10	12.38	6.66					
Ridepooling	-3.19	8.09	5.43	19.72				
Bicycle	-1.64	5.41	2.54	10.57	13.29			
Walking	-7.54	2.09	7.99	4.20	3.78	8.04		
Avoided trips	-0.50	-0.55	-5.73	0.26	2.41	3.36	-0.23	

Implied petrol price elasticity

The estimated model parameters can next be used to derive both the own-price elasticity of car travel as driver and the cross-price elasticity of public transport with respect to petrol prices (Tables 8 and 9). In this context, the reported percentage change in expected trip frequency refers to the percentage change in the model-predicted number of weekly trips relative to the status quo scenario. The petrol price adopted for the status quo is obtained by averaging the petrol price respondents reported paying the last time they filled up their tank, albeit the behavioural reference point remaining individual-specific.

The own-price elasticity estimates for car travel as driver are negative throughout, confirming that higher petrol prices reduce the expected number of driving trips. Of particular interest, however, is the variation in elasticity magnitude across the hypothetical price scenarios, which indicates that the behavioural response is not constant over the price range considered. This suggests that travellers do not respond to fuel price increases in a linear fashion. Instead, the implied elasticities point to a pattern in which driving becomes increasingly sensitive to petrol price changes as prices move further away from the respondent-specific reference point. In other words, relatively small increases above this reference point generate some contraction in driving, whereas larger increases are associated with stronger behavioural adjustment. This pattern is also evident in the associated percentage changes in expected trips: relative to the status quo, expected weekly driving trips decline by around 20 percent at AUD 2.50, 36 percent at AUD 3.00, and just over 50 percent at AUD 3.50.

Table 8: own-price elasticity of car travel as driver

Scenario	Average petrol price per litre	Number of weekly car trips	% change in expected trip frequency	Elasticity
Status quo	AUD 2.39	6.32	-	-
AUD 2.50	AUD 2.50	5.05	-20.06%	-4.99
AUD 3.00	AUD 3.00	4.01	-36.48%	-1.97
AUD 3.50	AUD 3.50	3.14	-50.31%	-1.78
		Average	**-35.62%**	**-2.92**

The corresponding cross-price elasticities for public transport are positive, indicating that higher petrol prices are associated with increased public transport use (Table 9). This is consistent with the mode-specific results discussed earlier, where public transport was the only alternative to display a clear and positive response at the higher fuel price scenarios. At the same time, the magnitude of the cross-price elasticity remains smaller than the corresponding own-price elasticity for car travel. This suggests that only part of the reduction in driving is absorbed by greater public transport use. Public transport therefore acts as an important substitute, but not a complete one. The percentage changes in expected public transport trips reinforce this interpretation. Compared to the status quo, expected weekly public transport trips increase by around 6 percent at AUD 2.50, 25 percent at AUD 3.00, and 31 percent at AUD 3.50. These demand changes indicate that rising petrol prices likely generate substitution effects, with some segments of the sample shifting away from driving towards public transport.

Table 9: cross-price elasticity of public transport (PT) with respect to petrol prices

Scenario	Average petrol price per litre	Number of weekly PT trips	% change in expected trip PT frequency	Elasticity
Status quo	AUD 2.39	1.85	-	-
AUD 2.50	AUD 2.50	1.96	5.97%	1.30
AUD 3.00	AUD 3.00	2.31	24.59%	0.97
AUD 3.50	AUD 3.50	2.42	30.58%	0.70
		Average	**20.38%**	**0.99**

Prospect theory interpretation

The implied price-response profile also enables travel behaviour to be interpreted through the lens of prospect theory. In this context, the relevant reference point is the petrol price each respondent reported paying during their most recent visit to a petrol station. Respondents were subsequently asked how their weekly trip frequencies would change under three hypothetical petrol price levels, AUD 2.50, AUD 3.00, and AUD 3.50 per litre. Owing to fluctuations in fuel prices during the survey period (outlined in the introduction), these hypothetical prices did not represent uniform changes for all individuals. For some respondents, the AUD 2.50 scenario represented an increase relative to their recently experienced fuel price, whereas for others it represented a decrease. Consequently, changes in predicted trips can be evaluated relative to an individually specific status quo, allowing behavioural responses to be interpreted in terms of gains and losses relative to a personal reference point.

A value of zero on the horizontal axis in Figure 2 corresponds to this reference point, with negative values indicating petrol prices below the respondent's most recently experienced price and positive values indicating petrol prices above it. From Figure 1 we can deduce that predicted trips decline as petrol prices rise above the reference point, but the decline is relatively gradual. By contrast, when prices move below the reference point, predicted trips increase more sharply. The dashed mirrored symmetry lines represent the hypothetical response patterns that would be expected if behavioural reactions to petrol price increases and decreases were perfectly symmetric around the reference point. In other words, they illustrate the benchmark case in which a price increase of a given magnitude would produce an equal but opposite behavioural response to a price decrease of the same magnitude. The deviations of the observed response curves from these mirrored lines therefore indicates asymmetric behavioural adjustment relative to the respondent-specific reference point. Behaviourally, this implies that the response to a price increase is not simply the inverse of the response to a price decrease of the same magnitude.

Further, it suggests that travellers do not adjust their behaviour in response to fuel price changes, but rather interpret those changes relative to a recent and personally benchmark. Additionally, the figure indicates that petrol price reductions appear to stimulate additional travel more strongly than petrol price increases suppress it. One plausible explanation is that many trips, especially those undertaken by car, are partly committed or difficult to avoid, so that the scope for reducing travel in response to price increases is limited. By contrast, lower-than-expected fuel prices may relax budgetary pressure and enable additional discretionary travel. The results point to a form of asymmetric reference-dependent behaviour rather than a simple symmetric price response. High fuel prices still reduce car travel and increase avoided trips, but the adjustment is moderated by the practical constraints that shape everyday mobility. This helps explain why rising petrol prices do not translate only into modal substitution, but also into a mix of muted car-use reduction, greater public transport uptake, and trip suppression.

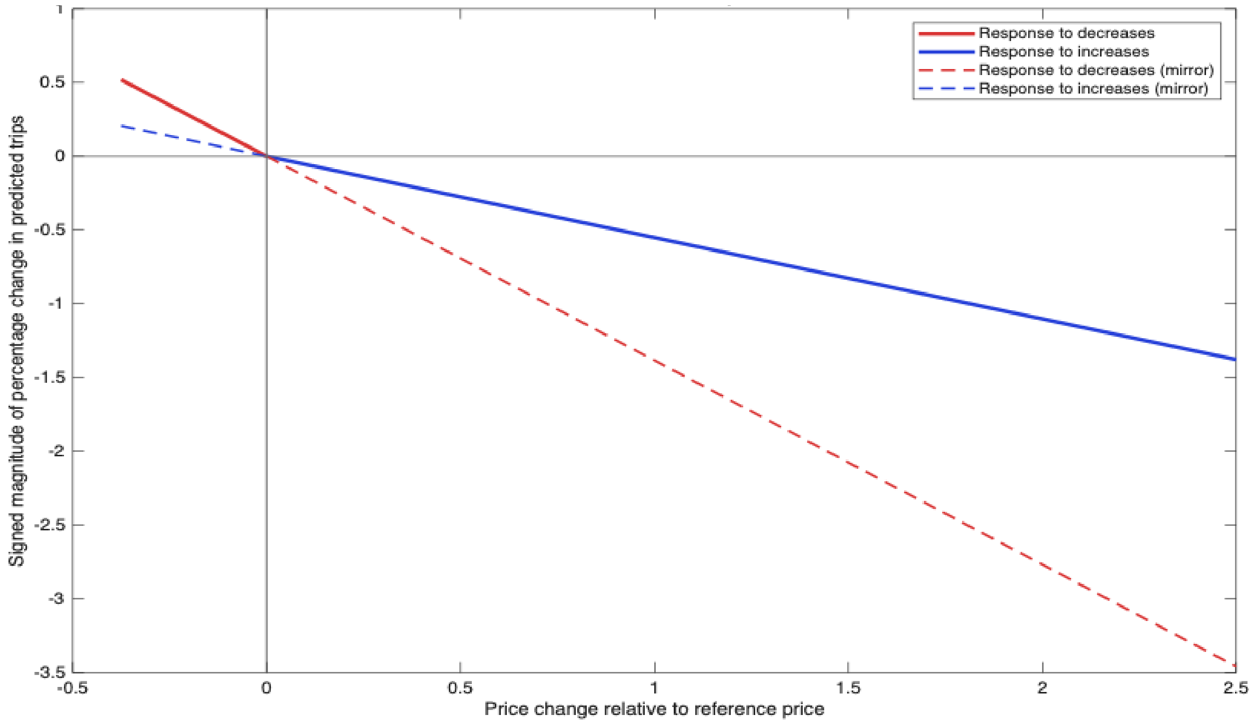

Figure 2: Changes in predicted trips as a function of changes in price relative to reported reference point

Discussion and Policy Implications

The results provide consistent evidence that rising petrol prices influence travel behaviour through a combination of modal substitution and mobility suppression. The most immediate adjustment occurs in car travel as driver, which declines monotonically as fuel prices increase across the hypothetical scenarios examined. Car travel as passenger also falls, indicating that higher fuel prices affect not only individual driving decisions but broader patterns of household reliance on private vehicle mobility. At the same time, the adjustment process is not characterised by a uniform shift toward all non-car modes. The strongest substitution effect is concentrated in public transport, which becomes significantly more attractive only at the higher petrol price scenarios. This suggests that public transport functions as a partial substitute for private vehicle travel once fuel prices move sufficiently above travellers' recent price experience. Other alternatives display weaker or mixed responses. Taxi use declines, walking also falls, and the remaining modes absorb only a limited share of displaced car travel. A key finding of the analysis is therefore that higher petrol prices do not simply redistribute travel across modes, but perhaps more importantly it also suppresses travel itself. The avoided-trips outcome increases substantially as fuel prices rise, indicating that some respondents respond by cancelling or foregoing trips altogether rather than substituting toward alternative transport options. This finding suggests that fuel price increases affect not only mode choice, but also the ability to maintain participation in out-of-home activities and everyday mobility.

The estimated TDC effects reinforce this interpretation. Greater perceived transport disadvantage is associated with lower public transport use and lower walking participation, suggesting that individuals facing existing mobility constraints are less able to adapt to higher fuel prices through modal substitution. The positive interaction effects with income indicate that financial resources partially moderate these constraints, implying that the behavioural burden associated with higher fuel prices is unevenly distributed across the population. The correlation structure further supports the interpretation that trip suppression represents a distinct behavioural adjustment rather than merely the residual counterpart of modal substitution. In particular, the negative residual correlation between avoided trips and public transport suggests that unobserved factors associated with greater transit accessibility or convenience reduce the likelihood of cancelling travel altogether. More broadly, the results imply that the ability to adapt to fuel price increases depends not only on income, but also on the practical availability of feasible transport alternatives.

The prospect theory interpretation additionally suggests that responses to fuel price changes are reference dependent rather than purely symmetric reactions to absolute price levels. Behavioural responses appear conditioned by recently experienced petrol prices, with lower-than-expected fuel prices stimulating additional travel more strongly than higher-than-expected prices suppress it. One plausible explanation is that many forms of travel are partly committed or constrained by everyday activity requirements, limiting the extent to which individuals can reduce mobility when fuel costs rise. By contrast, lower fuel prices may relax household budget constraints and enable additional discretionary travel. This pattern points toward constrained and asymmetric behavioural adaptation rather than fully flexible optimisation in response to changing transport costs.

The findings carry several important policy implications. They suggest that fuel price increases should not be interpreted solely as mechanisms for reducing private vehicle use. Although higher petrol prices reduce driving, a substantial share of behavioural adjustment occurs through suppressed travel rather than complete modal substitution. This implies that fuel price shocks may affect accessibility and participation in daily activities, particularly for individuals with limited transport alternatives. The results also point to potentially uneven spatial and social impacts of rising fuel prices. Individuals living in car-dependent environments, particularly in outer suburban and regional areas where public transport options are more limited, are likely to face greater difficulty adapting through modal substitution. Similarly, households already experiencing transport disadvantage may be disproportionately exposed to mobility loss when fuel prices rise. Fuel price shocks therefore have implications not only for transport demand, but also for transport equity and accessibility.

The results highlight the important role of public transport as a form of resilience against rising transport costs. Respondents with stronger connections to public transport appear less likely to suppress travel altogether, suggesting that accessible and affordable transit networks can buffer households against fuel price volatility. At the same time, the Queensland context provides an important qualification to this interpretation. Since August 2024, Queensland has operated a heavily subsidised flat-fare public transport system, substantially reducing the direct monetary cost of transit use well before the fuel price increases examined in this study. Despite this unusually low-fare environment, the increase in avoided trips still exceeds the observed shift toward public transport. This suggests that the barriers limiting substitution away from private vehicle travel are not purely financial. Even where public transport fares are very low, travellers may still face constraints related to service frequency, network coverage, accessibility, travel time, reliability, and the practical suitability of public transport for everyday activity participation. The findings therefore imply that improving affordability alone may be insufficient to induce large-scale behavioural substitution if the underlying accessibility and service quality of public transport remain limited.

More broadly, the findings suggest that policies relying primarily on higher fuel costs to encourage behavioural change may generate uneven welfare consequences unless accompanied by viable alternatives to private vehicle travel. While higher fuel prices may contribute to lower car use, the present results indicate that they may also reduce participation in social, discretionary, and potentially essential activities among some population groups. This highlights the importance of integrating transport affordability considerations into wider discussions surrounding cost-of-living pressures, transport disadvantage, and sustainable mobility transitions. Finally, the results indicate that behavioural responses to fuel prices are shaped not only by economic incentives, but also by habitual travel patterns, perceived accessibility, and recent price experiences. This indicates that transport demand responses may be more context-dependent and constrained than implied by standard symmetric elasticity interpretations. Consequently, future policy evaluation and travel demand forecasting may benefit from greater consideration of behavioural asymmetry, reference dependence, and mobility constraints when assessing responses to changing transport costs.

Concluding remarks

This paper examined how rising petrol prices influence weekly travel behaviour in Queensland, with particular attention to modal substitution and trip suppression. Using a multivariate Generalised Poisson framework with Gaussian copula dependence, the analysis jointly modelled eight travel outcomes, including an avoided-trips category specifically introduced to capture suppressed mobility under higher fuel price scenarios. The results show that rising petrol prices substantially reduce private vehicle travel and encourage greater public transport use, particularly at higher price levels. However, the adjustment process is only partially explained by modal substitution. A significant share of the behavioural response instead occurs through avoided trips, indicating that higher fuel prices may constrain mobility directly by leading individuals to cancel or forgo travel altogether.

The findings further demonstrate that these behavioural effects are unevenly distributed across the population. Individuals facing greater transport disadvantage appear less able to adapt through alternative modes, while stronger public transport accessibility reduces the likelihood of suppressing travel. The prospect theory interpretation additionally suggests that behavioural responses are reference dependent and asymmetric, with travellers responding relative to recently experienced fuel prices rather than solely to absolute price levels. The analysis contributes to the growing literature on transport affordability and cost-of-living pressures by showing that fuel price increases affect not only mode choice, but also the capacity of households to sustain participation in everyday activities. The findings therefore suggest that fuel price shocks should be understood not simply as transport cost changes, but as broader mobility and accessibility challenges with potentially unequal social consequences.

At the same time, several limitations should be acknowledged. First, the analysis is based on stated behavioural responses under hypothetical fuel price scenarios rather than observed revealed travel behaviour. Although this approach enables the examination of responses across a controlled range of fuel prices, stated intentions may not perfectly translate into realised behavioural adjustments. Second, the survey captures short-term behavioural expectations rather than longer-term adaptation processes, such as residential relocation, vehicle replacement, or sustained changes in activity participation. Third, while the avoided-trips category provides useful insight into mobility suppression, the analysis does not directly distinguish between discretionary and mandatory trips, nor does it explicitly measure the welfare consequences associated with forgone travel. These limitations point toward several directions for future research. Longitudinal revealed-preference data would help assess how behavioural responses evolve over time and whether temporary travel suppression becomes persistent behavioural change. Future work could also examine heterogeneity in responses across trip purposes, urban form, and levels of public transport accessibility. In addition, integrating measures of activity participation, wellbeing, or social exclusion would provide a deeper understanding of the broader consequences of rising transport costs beyond travel behaviour itself. Finally, further research could investigate the interaction between fuel prices, transport affordability policies, and accessibility conditions in shaping household resilience to future cost-of-living shocks.

REFERENCES

1. AIP (2026). Queensland state petrol price average. *Australian Institute of Petroleum*) https://www.aip.com.au/pricing/ULP/QLD/queensland-state-average, accessed 06/05/26.
2. Apanasovich, T.V., Ruppert, D., Lupton, J.R., Popovic, N., Turner, N.D., Chapkin, R.S. & Carroll, R.J. (2008). Aberrant crypt foci and semiparametric modelling of correlated binary data. *Biometrics*, 64(2), 490–500.
3. Beck, M. J., & Greaves, S. (2026). *A nexus or not? A first examination of cost-of-living concern, neighbourhood perceptions, active travel, and wellbeing in cities* (Working Paper ITLS-WP-26-14). Institute of Transport and Logistics Studies, The University of Sydney. https://ses.library.usyd.edu.au/handle/2123/34306
4. Belloc, I., Giménez-Nadal, J. I., & Molina, J. A. (2024). The gasoline price and the commuting behavior of US commuters: Exploring changes to green travel mode choices. *Journal of Transport Geography*, 120, 104006.
5. Bhat, C.R., Varin, C. & Ferdous, N. (2010). A comparison of the maximum simulated likelihood and composite marginal likelihood estimation approaches in the context of the multivariate ordered response model. In W. Greene & R. C. Hill (Eds.), *Advances in Econometrics: Maximum Simulated Likelihood Methods and Applications* (Vol. 26, pp. 65–106). Emerald Group Publishing.
6. Chen, C., Varley, D., & Chen, J. (2011). What affects transit ridership? A dynamic analysis involving multiple factors, lags and asymmetric behaviour. *Urban Studies*, 48(9), 1893–1908.

7. Church, A., Frost, M., & Sullivan, K. (2000). Transport and social exclusion in London. *Transport Policy, 7*(3), 195–205.
8. Consul, P.C. & Jain, G.C. (1973). A generalization of the Poisson distribution. *Technometrics*, 15(4), 791–799.
9. Consul, P.C. & Shoukri, M.M. (1984). Maximum likelihood estimation of the generalized Poisson distribution. *Communications in Statistics—Theory and Methods*, 13, 1533–1547.
10. Currie, G., & Delbosc, A. (2010). Modelling the social and psychological impacts of transport disadvantage. *Transportation, 37*(6), 953–966.
11. Currie, G., Richardson, T., Smyth, P., Vella-Brodrick, D., Hine, J., Lucas, K., Stanley, J., Morris, J., Kinnear, R., & Stanley, J. (2010). Investigating links between transport disadvantage, social exclusion and well-being in Melbourne—Updated results. *Research in Transportation Economics, 29*(1), 287–295.
12. Dabrowski, V., Atas, N., Ramsey, T., & Howarth, N. (2025). 'Money anxiety': Understanding HE students' experiences of the cost-of-living crisis. *Social Policy & Administration*, 59(2), 280–292.
13. Diamantopoulos, A., & Winklhofer, H. M. (2001). Index construction with formative indicators: An alternative to scale development.*Journal of Marketing Research, 38*(2), 269–277.
14. Fountas, G., Fonzone, A., & Olowosegun, A. M. (2025). The impact of the cost-of-living crisis on travel choices: The case of Scotland. *Research in Transportation Economics*, 110, 101537.
15. Godambe, V. (1960). An optimum property of regular maximum likelihood equation. *Annals of Mathematical Statistics*, 31, 1208–1211.
16. Jarvis, C. B., MacKenzie, S. B., & Podsakoff, P. M. (2003). A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of Consumer Research, 30*(2), 199–218.
17. Lindsay, B.G. (1988). Composite likelihood methods. *Contemporary Mathematics*, 80, 221–239.
18. Lucas, K., Mattioli, G., Verlinghieri, E., & Guzman, A. (2016). Transport poverty and its adverse social consequences. Proceedings of the Institution of Civil Engineers: Transport, 169(6), 353–365.
19. Ma, L., Kent, J. L., & Mulley, C. (2016). *Transport disadvantage, social exclusion and subjective wellbeing: The role of built environment—Evidence from Sydney, Australia*. In Australasian Transport Research Forum 2016 Proceedings (16–18 November 2016, Melbourne, Australia)
20. Martens, K. (2016). *Transport justice: Designing fair transportation systems* (1st ed.). Routledge.
21. Masarotto, G. & Varin, C. (2017). Gaussian copula regression in R. *Journal of Statistical Software*, 77(8), 1–26.
22. Mily, S. N., Haque, M. B., & Islam, M. A. (2024). Unveiling the consequence of unprecedented fuel price hike in Bangladesh on consumer travel behavior. *Sustainable Transport and Livability*.

23. Organisation for Economic Co-operation and Development (OECD), & European Commission Joint Research Centre. (2008). *Handbook on constructing composite indicators: Methodology and user guide*. OECD Publishing.
24. Queensland Government (2024a). Miles plan to bust congestion: Public transport (almost) free. Joint statement published 26 May 2024. https://statements.qld.gov.au/statements/100402 (accessed 23 December 2025).
25. Queensland Government (2024b). The Crisafulli Government Makes 50 Cent Public Transport Fares Permanent. Media statement published 30 November 2024. https://statements.qld.gov.au/statements/101663 (accessed 23 December 2025).
26. Rose, J. M., Borriello, A., & Pellegrini, A. (2023). Formative versus reflective attitude measures: Extending the hybrid choice model. *Journal of Choice Modelling, 48*, 100412.
27. Rose, J.M., Pellegrini, A., Hensher, D.A., & Beck, M.J. (2025). LOW COST FLAT PUBLIC FARE POLICY: INDUCED DEMAND, MODE SWITCHING AND POLICY BENEFICIARIES. Institute Of Transport and Logistics Studies (ITLS) Working Papers Series, The University of Sydney Business School.
28. Saadi, D., & Martens, K. (2025). Determining people's ease and difficulty of movement based on observed travel behavior. *Transportation*
29. Saberi, M., Wu, H., Amoh-Gyimah, R., Smith, J., & Arunachalam, D. (2017). Measuring housing and transportation affordability: A case study of Melbourne, Australia. *Journal of Transport Geography, 65*, 134–146. https://doi.org/10.1016/j.jtrangeo.2017.10.007
30. Syed, I. U., & da Silveira Gorman, R. (2025). Astronomical cost of living: Challenging housing, transportation and commuting experiences among care workers. *Critical Public Health*, 35(1).
31. Tiznado-Aitken, I., Lucas, K., Muñoz, J. C., & Hurtubia, R. (2022). Freedom of choice? Social and spatial disparities on combined housing and transport affordability. *Transport Policy*, 122, 39–53.
32. Vidyattama, Y., Tanton, R., & Nepal, B. (2013). The effect of transport costs on housing-related financial stress in Australia. *Urban Studies*, 50(9), 1779–1795
33. Wang, W. & Famoye, F. (1997). Modeling household fertility decisions with generalized Poisson regression. *Journal of Population Economics*, 10(3), 273–283.
34. Xi, H., Nelson, J. D., Mulley, C., Hensher, D. A., Ho, C., & Balbontin, C. (2025). Addressing transport disadvantages in regional and rural areas through integrated mobility services. *Research in Transportation Economics, 114*, 101650.
35. Xiao, R., Wang, G., & Wang, M. (2018). Transportation disadvantage and neighborhood sociodemographics: A composite indicator approach to examining social inequalities. *Social Indicators Research, 137*(1), 29–43.
36. Zhao, Y. & Joe, H. (2005). Composite likelihood estimation in multivariate data analysis. *The Canadian Journal of Statistics*, 33, 335–356.