Effect of Raising Fuel Price on Reduction in Household Transport Greenhouse Gas Emissions: A Sydney Case Study

Junjian Zhao[1], Alan Peters[1] and Peter Rickwood[2]
[1]Faculty of the Built Environment, University of New South Wales, NSW 2052, Australia
[2]Institute for Sustainable Futures, University of Technology, Sydney, NSW 2007, Australia
Email for correspondence: junjian.zhao@student.unsw.edu.au

Abstract: The purpose of this paper was to investigate the relationship between fuel price, land use characteristics and household travel green house gas (GHG) emissions in Sydney, and determine fuel price policy implications to efficiently reduce overall travel GHG emissions in the short-term, taking into account social equity. There were three main findings. Firstly, econometric analysis revealed that household travel emissions was reduced as fuel price increased, and the effect of fuel price change could vary substantially across the whole metropolitan area, and households living in higher density areas have higher fuel elasticity in terms of reducing travel emissions. Scenario analysis showed that, to some extent, raising fuel price effectively reduced overall travel GHG emissions in the short-term; however, the marginal effect of raising price on emissions reduction showed a decrease and the effect of implementing fuel price policy only was limited. A greater reduction effect could be achieved long-term through the combination of fuel price policy and land use policy. Thirdly, a proportion of poor socioeconomic households were in the highest emissions quintile, with car emissions very high among their overall emissions. This suggests that care should be taken when implementing fuel price policies to ensure that such households are not negatively impacted.

1. Introduction

The transport sector's share in the overall emissions continues to increase, with the sector responsible for about 14.4% of total GHG emissions in Australia, of which road transport accounts for 89.2% (AGO, 2007). To mitigate climate change, policy makers are in search of strategies to reduce road transport emissions.

Generally speaking, there are three kinds of policies that can potentially reduce household travel GHG emissions, namely, technology, land use, and pricing policies. Technology policies mainly target improving vehicle fuel efficiency and reducing GHG emissions per VKT. However, many studies have revealed that raising vehicle efficiency has a 'Rebound Effect' and the effect of technology policies on travel GHG emissions is controversial (Gillingham, et al., 2013). Therefore, urban planners typically focused on the two other policies, and assumed that changing urban land use characteristics and fuel costs impacted travel behaviour and corresponding travel GHG emissions. While land use policy typically targets at only some parts of the metropolitan area and takes a relatively long time period (built environment changes relatively slowly compared to fuel price change) to affect travel behaviours, fuel price policy targets at the whole metropolitan area and can have effect on people's travel behaviours in a relatively short time period. Table 1 makes a comparison of these two kinds of policies in terms of temporal and spatial scales. Therefore, in the following parts of this paper, we assumed that in the short-term, only price policy could take effect, and in the long-term, these two kinds of policies could take effect together on travel behavior.

Table 1: Comparison of effects of fuel price policy and land use policy

	Spatial scale	Temporal scale
Fuel price policy	global	short
Land use policy	local	long

To provide evidence for policy implementation, it is essential to understand what factors (i.e. household socioeconomic characteristics, land use factors and travel price) impact household travel GHG emissions in Australian cities and to what extent. Numerous studies (e.g. Corpuz et al., 2006; Alford et al., 2008; Rickwood, 2009; Ellis et al., 2010; Paez et al., 2010; Raimond et al., 2010; Shin et al., 2010; Silva et al., 2010; Wiblin, 2010; Woodruff et al., 2010; Xu et al., 2010; Burke et al., 2011; Li et al., 2011; Silva et al., 2011; Mckibbin, 2011; Tsang et al., 2011; Hay et al., 2012; Shobeirinejad et al., 2012; Tsai et al., 2012) have been undertaken to investigate the factors that impact urban passenger travel behaviour and the resulting energy consumption and GHG emission in Australian cities.

Despite extensive reports in the literature, several research gaps still exist. Most studies have assessed the effect of household or personal socio-economic and spatial characteristics on only a subset of travel decisions that affect GHG emissions, rather than GHG emissions itself. For instance, some studies have evaluated the effect of household characteristics on the number or type of vehicles owned, while others have evaluated the effect on travel distance or mode choice. In terms of travel purposes, most studies have evaluated the effect on one travel purpose such as commuting, with few studies estimating the effect on all travel purposes. In terms of emissions reduction policies, the majority of Australian research has examined either land use or price policies, rarely looking at both policy types simultaneously or exploring their 'synergistic' effects. Excluding such research may limit our understanding of the real effects of land use policies and price polices.

The main objective of this paper was to investigate the relationship between fuel price, land use characteristics and household travel GHG emissions in the Sydney Metropolitan Area, and raise some fuel price policy implications to efficiently reduce overall travel GHG emissions. The specific objectives of this research were to: (1) investigate the relationship between GHG emissions and a variety of household socio-economic characteristics, land use characteristics and fuel price using a multivariate regression model; (2) develop methodology to calculate overall household transport GHG emissions for the Metropolitan Area by using the developed econometric model and Kriging Interpolation Method; and, (3) discuss policy implications for the reduction of passenger travel GHG emissions in Sydney, taking into consideration social equity.

2. Factors that may influence household travel GHG emission

The literature on travel behaviour points out that travel costs, household socio-economic characteristics, and locational and land use factors impact household travel behaviour such as travel mode choice and VKT (Cervero et al., 1997; Greening, 1997; Schwanen et al., 2001; Stead, 2001; Stead et al., 2001; Brand et al., 2010; Ewing et al., 2010; Barla et al., 2011; Dieleman et al., 2011; Kamruzzaman et al., 2011; Lindsey et al., 2011; Zahabi et al., 2012; Lee, 2012).

In a review and evaluation of the relationships between urban form and travel patterns, Stead et al. (2001) discussed nine aspects of urban form, ranging from regional strategic planning level to specific local planning issues at the neighbourhood scale that impacted household travel behaviour. These factors included distance of residence from urban centre, settlement size, mixing of land uses, provision of local facilities, density of development, proximity to transport networks, availability of residential parking, road network type and neighbourhood type.

In a review of the relationships between socio-economic characteristics and travel behaviour, Stead (2001) found that eleven main socio-economic factors may impact travel patterns and the resulting transport GHG emissions, that is, income; car ownership and availability; possession of a driver licence; working status; employment type; gender; age; household size and composition; level of education and attitudes; and personality type.

3. Methodology

Sydney Household Travel Survey (HTS) data was used in this study. The HTS was first conducted in 1997/98 and has been running continuously since then. Approximately 8,500 people in 3,500 households in the Sydney Greater Metropolitan Area (including the Sydney and Illawarra Statistical Divisions and Newcastle Statistical Subdivision) participate in the survey annually. Each member of the household is asked to fill in a travel diary for one day. The data includes trip information such as origin, destination, purpose, mode, time, costs, personal information such as age, gender, employment status and income, household information such as household and family type, dwelling structure, number of vehicles, and vehicle information such as make, model, fuel type, and vehicle ownership. The 2006-2010 HTS data were analysed in the present study. Overall, a total of 11,963 households in the Sydney Metropolitan Area (Sydney SD) were selected in our study.

In addition to the HTS data, we also obtained monthly average unleaded petrol (ULP) price from MotorMouth (http://motormouth.com.au/), land use characteristics data from the Australian Bureau of Statistics (ABS) Mesh Block data, and number of households, population and employment density from the New South Wales Bureau of Transport Statistics (BTS).

The following steps were implemented in this study:

(1) Household transport GHG emissions were calculated.
(2) Main land use characteristics at the Travel Zone (TZ) level were calculated.
(3) An econometric model at the TZ level was developed.
(4) Total household travel GHG emissions for the Sydney Metropolitan Area were calculated.
(5) Fuel price policy scenarios to reduce household travel GHG emissions were analysed.
(6) Travel emission patterns of the socioeconomically disadvantaged group were analysed.

3.1. Calculation of household transport GHG emissions

Seven modes of travel that emit GHG were considered in this research, including private motor vehicle (including car and motorcycle), taxi, bus, train, monorail, light rail and ferry. Detailed calculation steps and data requirements were as per Zhao et al. (2013). We first calculated emissions for each trip, and then aggregated trip emissions to personal and household levels. Average household GHG emissions were then calculated for the 1,693 sampled TZs. To increase the representativeness of the data, only TZs with five or more households were selected for further analysis, which included 10,472 households (87.5% of 11,963 sampled households) in 1,181 TZs (69.8% of 1,693 sampled TZs).

3.2. Calculation of main land use characteristics at TZ level

Land use characteristics (distance to CBD, land use mix, population and employment density) were calculated according to previous literature and data availability. Euclidean distances between the centroid of TZs and the Centre Point Tower were used to represent the relative location of the TZs with the CBD. The entropy method was used for land use mix. Detailed calculation steps and data used were introduced in our previous paper (Zhao et al., 2013).

3.3. Econometric model at TZ level

3.3.1. Hypothesis: That is, a certain increase in fuel price has different effects on travel GHG emissions of households in locations with different land use characteristics across the metropolitan area. For example, when fuel price increases, people in locations with higher density, higher land use diversity and higher public transport accessibility could switch their travel mode from private vehicle to public transport or walking more easily than people living in locations with lower density, lower land use diversity, or lower public transport accessibility, resulting in more emissions reduction.

3.3.2. Model development

The study model was established as follows:

$$E = C + \sum_{i=1}^{n} a_i x_i + \sum_{j=1}^{m} b_j y_i + k * Ln(p) + \sum_{i=1}^{n} (c_{i1}x_i + c_{i2}x_i^2 + c_{i3}x_i^3) * Ln(p) \cdots\cdots \quad \text{(Equation 1)}$$

Where, E is the average household transport emissions of a certain TZ, C is the intercept, n is the total number of land use variables, a_i is the coefficient of the ith land use variable, x_i is the value of the ith land use characteristic of the TZ, m is the total number of socioeconomic variables, b_j is the coefficient of the jth socio-economic variable, y_j is the average value of the jth socio-economic characteristic of the TZ, p is the average fuel price for the TZ, k is the coefficient of p, and c_{i1}, c_{i2} and c_{i3}, are the coefficients.

In Equation 1, $\sum_{i=1}^{n} a_i x_i$ represents the effects of various land use characteristics on household travel GHG emissions. $\sum_{j=1}^{m} b_j y_i$ represents the effects of a variety of socioeconomic characteristics on household travel emissions. $k * Ln(p)$ represents the effect of fuel price on household travel emissions, and $\sum_{i=1}^{n}(c_{i1}x_i + c_{i2}x_i^2 + c_{i3}x_i^3) * Ln(p)$ represents the 'synergistic' effects of land use characteristics and fuel price on household travel emissions. As the most commonly used splines (mathematics) are cubic spline (i.e., order 3), we set 3 as the order of polynomial functions $(c_{i1}x_i + c_{i2}x_i^2 + c_{i3}x_i^3)$.

This model structure was informed by the existing literature on travel behaviour, as well as the authors' judgement, and fit to data.

For land use characteristics, distance to CBD (km), population density (persons per hectare), employment density (persons per hectare) and land use mix were used as independent variables. At present, we are still collecting detailed and timely data to develop measures of public transport access to make the model as accurate as possible. However, Rickwood and Glazebrook (2009) showed that distance from the CBD and local area density was a very close substitute for a detailed public transport accessibility measure (developed in Glazebrook 2002). In addition, Rickwood (2009) developed a travel model based on car ownership, local area density, and distance to the CBD, as he finds that other specific measures of service frequency (distance to nearest centre, distance to high-frequency stop) give little additional predictive accuracy, just as Glazebrook's accessibility index gives little additional explanatory power over distance from CBD and local area density.

For socioeconomic variables, the average socioeconomic variables of a TZ were used. The average number of residents, number of adults, number of children, number of full-time workers, number of part-time workers, number of driver licences, number of vehicles, and household income ($10,000) were included as independent variables. For fuel price, the unleaded petrol price (cents/L) was obtained for each household based on the surveyed travel day. These amounts were then averaged at the TZ level. A summary of the above variables is shown in Table 2.

Table 2. Summary of dependent and independent variables

	N	Minimum	Maximum	Mean	Std. Deviation
Emission (kg)	1181	.04	41.12	10.09	6.04
Distance to CBD (km)	1181	.44	88.75	23.98	17.75
Population density (persons/hectare)	1181	.00	59.84	23.76	15.09
Employment density (persons/hectare)	1181	.00	149.98	39.06	33.76
RESIDENT_NUM	1181	1.00	4.80	2.68	.66
RESIDENT_NUM_ADULT	1181	1.00	4.00	2.12	.44
RESIDENT_NUM_CHILD	1181	.00	2.80	.56	.40
LAND_USE_MIX	1181	.00	.75	.35	.13
FT_WORKER_NUM	1181	.00	2.57	.95	.36
PT_WORKER_NUM	1181	.00	1.20	.26	.19
HH_INCOME	1181	12898.22	197834.25	80677.95	30156.00
USUAL_VEHICLE_NUM	1181	.00	3.57	1.57	.57
LICENCE_NUM	1181	.00	3.60	1.79	.48
Price (cents/L)	1181	109.05	160.60	128.33	9.20
Valid N (listwise)	1181				

3.4. Calculation of total household travel GHG emissions for Sydney Metropolitan Area

The developed model (section 3.3.2) was used to calculate overall emissions of the Sydney Metropolitan Area, as follows:

(1) The initial value P was set as the fuel price.
(2) The developed model was used to calculate average household travel GHG emissions for the 1,181 sampled Travel Zones, the values were placed on a spatial map, and each value was assigned to the Travel Zone centroid.
(3) Using ArcGIS10.1, the Kriging Interpolation Method was used to produce a raster layer for the average values generated from (2). The raster layer was converted into vector dot coverage. For the remaining 1,096 Travel Zones, the nearest point to each Travel Zone centroid was found in the vector dot coverage, and the value represented by the points was assigned to the Travel Zone centroid as the average value of the 1,096 Travel Zones.
(4) After average household emissions for each TZ were obtained for the Metropolitan Area, the averages of household emissions of were multiplied by the household number of each TZ to obtain the average total daily emissions for each TZ.
(5) The results aggregated from (4) were the total amount of emissions in the Metropolitan Area.

4. Model results

We used SPSS 21 to perform stepwise regression analysis, with the derived model shown in Table 3 and Table 4. This model had the best adjusted R Square of any model considered, but we include several intermediate models in a separate technical appendix, for those interested in alternative specifications.

Table 3. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
8	.752[a]	.566	.563	3.99270	.566	191.081	8	1172	.000

Table 4. Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	1.574	1.073		1.467	.143
	USUAL_VEHICLE_NUM	2.871	.411	.269	6.988	.000
	LICENCE_NUM	1.233	.526	.097	2.345	.019
	Distance_km	.030	.013	.088	2.358	.019
8	FT_WORKER_NUM	2.329	.402	.140	5.793	.000
	RESIDENT_NUM	1.346	.258	.147	5.221	.000
	Ln_Price_Density	-.088	.014	-1.064	-6.137	.000
	Ln_Price_Density_2	.002	.001	1.419	3.713	.000
	Ln_Price_Density_3	-1.617E-005	.000	-.621	-2.564	.010

a. Dependent Variable: Emission

An R Square of 0.566 was achieved by the model, as shown in Table 3, indicating that the fit of the model was quite good. Table 4 shows that only eight items were left in the model. The model could be expressed as the following equation:

$$Emission = 1.574 + 2.871 \times \text{Vehicle Number} + 1.233 \times \text{Licence Number} + 0.030 \times \text{Distance to CBD}$$
$$+2.329 \times \text{Fulltime Worker Number} + 1.364 \times \text{Residents Number}$$
$$+(-0.088 \times \text{Density} + 0.002 \times Density^2 - 1.617 \times 10^{-5} \times Density^3) \times \text{Ln(Price)}$$

(Equation 2)

Here, density is the population density of TZ.
From Equation 2, we obtained the partial derivative:

$$\frac{\partial(Emission)}{\partial(Price)} = \frac{1}{Price}(-0.088 \times \text{Density} + 0.002 \times Density^2 - 1.617 \times 10^{-5} \times Density^3) \quad \text{(Equation 3)}$$

Then,

$$\frac{\Delta(Emission)}{\Delta(Price)/Price} = f(Density) = (-0.088 \times \text{Density} + 0.002 \times Density^2 - 1.617 \times 10^{-5} \times Density^3) \quad \text{(Equation 4)}$$

In Equation 4, when density >0.006 persons/hectare, $f(\text{Density})<0$, and when the density increased, $f(\text{Density})$ decreased. This suggests two points:
(1) Increasing fuel price could reduce travel emissions; and

(2) There was higher fuel price elasticity for households in higher density areas in terms of reducing emissions.

Although land use policies were less effective in the short-term than fuel price change, because the physical urban environment changed relatively slowly compared to fuel price change, long-term applications of land use policies made a difference that pricing policies alone could not attain. Therefore, both land use and pricing policies were important to the reduction of household travel emissions.

5. Short-term price policy scenarios
Due to the slower changes in the physical urban environment compared to fuel price changes, we assumed that only price policy had an effect in the short-term, which raises some price policy implications.
We set December 2012 as the original status. From the MotorMouth website, the average ULP price for that month was 139.5 cents. Six policy scenarios were examined, that is, raising the fuel price by 5 cents/L, 10 cents/L, 15 cents/L, 20 cents/L, 25 cents/L and 30 cents/L.
The study model suggested that the relationship between fuel price and travel emissions was not linear. The overall emissions were predicted (see Section 3.4) for each policy scenario. Table 5 shows the different reduction scenarios of the different price policies.

Table 5. Different fuel price scenarios

Scenarios	Fuel Price (cents/L)	Total Emissions (1,000,000 kg CO2e)	Emissions Reduction (1,000 kg CO2e)	Reduction Percentage (%)	Average Emissions Reduction per cent/L increase of fuel price (1,000 kg CO2e)
original status	139.5	14.72			
5 cents up	144.5	14.62	101.3	0.7	20.3
10 cents up	149.5	14.57	158.6	1.1	15.9
15 cents up	154.5	14.51	210.7	1.4	14.0
20 cents up	159.5	14.46	264.8	1.8	13.2
25 cents up	164.5	14.40	319.7	2.2	12.8
30 cents up	169.5	14.35	371.7	2.5	12.4

Table 5 demonstrates that if policy makers raised the fuel price by 5 cents/L and 10 cents/L, the overall household travel emissions could be reduced by 0.7% and 1.1%, respectively. If the fuel price was raised by 30 cents/L, total emissions could be reduced by 2.5%. This suggests that fuel price changes had an effect on reducing travel emissions to some extent.

However, the marginal reduction effect of raising fuel price decreased when the price increase was higher than 5 cents, and then remained relatively similar when price was raised by 10 cents/L to 30 cents/L. This suggests that the effect of implementing fuel price policy alone was limited, and a more significant reduction effect could be achieved long-term through the combination of fuel price and land use policies.

6. Travel emissions and socioeconomically disadvantaged group

We also examined the travel emissions characteristics of the socioeconomically disadvantaged group because it is likely that emission reduction policies such as increasing fuel costs may impact their economic conditions.

6.1. Brief identification of socioeconomically disadvantaged group

In this study, we identified socioeconomic disadvantage by taking into account data availability and needs for pricing policy.

The ABS developed an Index of Relative Socio-economic Disadvantage using Australian census data. However, the HTS data consists of fewer socioeconomic variables than that of the census. Therefore, it was not practical to develop a socioeconomic disadvantage index for the households in our sample. In addition, the implementation of pricing policies directly impacts the economic conditions of the households. Therefore, we selected equivalised household income as the standard to identify households of different economic status. Households with annual equivalised income between $13,000 and $20,799 were identified as socioeconomically disadvantaged (second and third equivalised income deciles). It is ABS standard practice to use the second and third income deciles as a low income group because of the varying financial circumstances of people in the lowest income decile (ABS, 2007). Using this standard, there were 1,805 socioeconomically disadvantaged households in our study.

6.2. Highest emissions quintile

We ranked the 11,963 households in our sample by their household travel emissions, and divided them into five quintiles. We found that the highest 20% of households accounted for a surprisingly high proportion (57.3%) of the overall travel emissions, while the lowest 20% of emitters accounted for only 0.3% (Figure 1). These results suggested that emissions were distributed quite unevenly among households, and that it may make sense to pay specific attention to large emitters.

It is also important to look at the emissions patterns of the socioeconomically disadvantaged in the highest emissions quintile, as this group would be strongly affected by changes to fuel price.

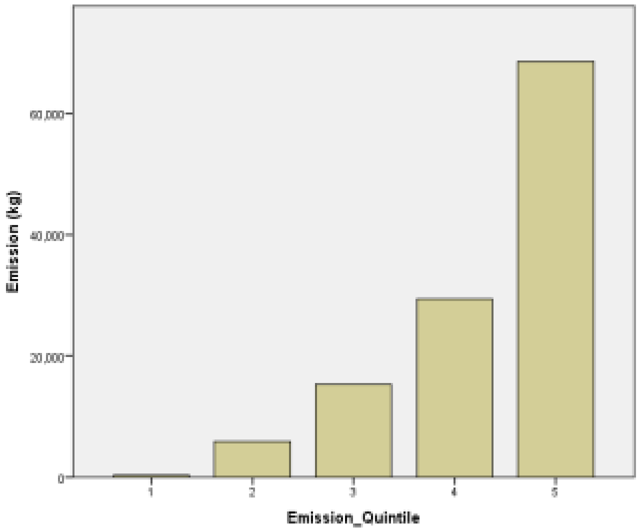

Figure 1. Emissions by quintile

6.3. Comparison of emission patterns between different groups

We selected the following four household groups to compare their emission characteristics: (1) all 11,963 households, (2) socioeconomically disadvantaged group (1805 households), (3) highest emissions quintile households (2392 households), and (4) socioeconomically disadvantaged group in the highest emissions quintile (142 households). Their emissions characteristics are listed in Table 6.

Table 6. Emission patterns of different groups

	Number of households	Average emissions (kg CO2e)	Average emissions by car (kg CO2e)	Percentage of car emissions
Overall households	11963	10.0	8.8	87.6%
SE disadvantaged	1805	5.7	4.6	80.8%
Highest emissions quintile	2392	28.7	25.6	89.4%
SE disadvantage in highest quintile	142	30.2	23.4	77.5%

Table 6 shows the following:

(1) Car dominates overall emissions among all the groups, with more than three quarters of emissions from cars.
(2) The socioeconomically disadvantaged households on average have lower emissions than people in better socioeconomic conditions.
(3) There are still a small proportion of socioeconomically disadvantaged households (142 out of 1805, in our sample) in the highest quintile. This group of households should be taken into account when implementing price policies, as the impact of fuel pricing would be substantial, given their low income and high fuel use.

7. Conclusions and Discussion

This paper investigated the relationship between fuel price, land use characteristics and household travel GHG emissions in the Sydney Metropolitan Area, and discussed fuel price policy implications to efficiently reduce overall travel GHG emissions in short-term. There were three main findings. Firstly, econometric analysis revealed that household travel emissions was reduced as fuel price increased, and the effect of fuel price change could vary substantially across the whole metropolitan area, and households living in higher density areas have higher fuel elasticity in terms of reducing travel emissions. Secondly, because the physical urban environment changed relatively slowly compared to fuel price changes, we assumed that short-term price policy alone had an effect on the reduction of household travel GHG emissions. Scenario analysis showed that increasing the fuel price effectively reduced overall travel GHG emissions in the short-term; however, the marginal effect of raising prices on emissions reduction decreased and the effect of implementing fuel price policy alone was limited. Accordingly, a greater reduction effect could be achieved long-term through the combination of fuel price policy and land use policy. Thirdly, a proportion of poor socioeconomic households were found in the highest emissions quintile, with car emissions accounting for a very high percentage of overall emissions. This suggested that care should be taken when implementing fuel price policy to ensure their economic situation is not further impacted.

Due to the data availability, there are some limitations in developing the model at this stage. Firstly, though the HTS dataset contains a quite big number of households in the metropolitan area, the average household number of travel zones (7 households per TZ) is still not big enough. If there were more sampled households, the representativeness of the HTS data would be better. Secondly, the fuel price used in this paper is from the MotorMouth website, and only monthly average fuel price was obtained to roughly represent travel costs. If more accurate data such as weekly or daily average fuel price could be obtained, the model results would be better. Thirdly, we used distance from the CBD and local area density as a close substitute for a detailed public transport accessibility measure. Although this was supported by literature (Rickwood and Glazebrook, 2009), at present, we are still collecting detailed data to develop measures of public transport access to make the model as accurate as possible. And when we are going to determine land use policies in the next stage, it is also required more land use variables such as public transport access be included in the model.

As introduced in the beginning of this paper, fuel price policy and land use policy are two kinds of policies that could reduce household travel GHG emissions. This paper discussed fuel price policy in short term, and we are currently conducting further research to clarify how to effectively increase the long-term reduction in emissions under simultaneous land use and price policies when resources to implement land use policies are limited.

Acknowledgements

The main data used in this study was obtained from the Household Travel Survey (HTS) dataset from the New South Wales Bureau of Transport Statistics (BTS). The authors wish to thank the BTS for providing permission to use the HTS data for analysis.

Appendix: Alternative regression models

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
5	.740[e]	.548	.546	4.06972
6	.750[f]	.562	.560	4.00866
7	.751[g]	.564	.561	4.00035
8	.752[h]	.566	.563	3.99270

e. Predictors: (Constant), USUAL_VEHICLE_NUM, Distance_km, FT_WORKER_NUM, RESIDENT_NUM, Ln_Price_Density

f. Predictors: (Constant), USUAL_VEHICLE_NUM, Distance_km, FT_WORKER_NUM, RESIDENT_NUM, Ln_Price_Density, Ln_Price_Density_2

g. Predictors: (Constant), USUAL_VEHICLE_NUM, Distance_km, FT_WORKER_NUM, RESIDENT_NUM, Ln_Price_Density, Ln_Price_Density_2, Ln_Price_Density_3

h. Predictors: (Constant), USUAL_VEHICLE_NUM, Distance_km, FT_WORKER_NUM, RESIDENT_NUM, Ln_Price_Density, Ln_Price_Density_2, Ln_Price_Density_3, LICENCE_NUM

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
5	Regression	23591.707	5	4718.341	284.879	.000[f]
	Residual	19461.085	1175	16.563		
	Total	43052.792	1180			
6	Regression	24187.333	6	4031.222	250.863	.000[g]
	Residual	18865.459	1174	16.069		
	Total	43052.792	1180			
7	Regression	24281.505	7	3468.786	216.761	.000[h]
	Residual	18771.287	1173	16.003		
	Total	43052.792	1180			
8	Regression	24369.182	8	3046.148	191.081	.000[i]
	Residual	18683.610	1172	15.942		
	Total	43052.792	1180			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
5	(Constant)	-2.062	.898		-2.297	.022
	USUAL_VEHICLE_NUM	3.893	.312	.365	12.462	.000
	Distance_km	.065	.011	.190	5.694	.000
	FT_WORKER_NUM	2.774	.395	.166	7.032	.000
	RESIDENT_NUM	1.265	.226	.138	5.606	.000
	Ln_Price_Density	-.013	.003	-.161	-4.432	.000
6	(Constant)	1.100	1.026		1.073	.284
	USUAL_VEHICLE_NUM	3.529	.313	.331	11.261	.000
	Distance_km	.029	.013	.084	2.262	.024
	FT_WORKER_NUM	2.572	.390	.154	6.593	.000
	RESIDENT_NUM	1.617	.230	.177	7.042	.000
	Ln_Price_Density	-.057	.008	-.686	-7.345	.000
	Ln_Price_Density_2	.001	.000	.457	6.088	.000
7	(Constant)	1.845	1.069		1.727	.084
	USUAL_VEHICLE_NUM	3.497	.313	.328	11.172	.000
	Distance_km	.027	.013	.079	2.119	.034
	FT_WORKER_NUM	2.570	.389	.154	6.603	.000
	RESIDENT_NUM	1.626	.229	.178	7.095	.000
	Ln_Price_Density	-.086	.014	-1.041	-6.003	.000
	Ln_Price_Density_2	.002	.001	1.366	3.573	.000
	Ln_Price_Density_3	-1.530E-005	.000	-.587	-2.426	.015
8	(Constant)	1.574	1.073		1.467	.143
	USUAL_VEHICLE_NUM	2.871	.411	.269	6.988	.000
	Distance_km	.030	.013	.088	2.358	.019
	FT_WORKER_NUM	2.329	.402	.140	5.793	.000
	RESIDENT_NUM	1.346	.258	.147	5.221	.000
	Ln_Price_Density	-.088	.014	-1.064	-6.137	.000
	Ln_Price_Density_2	.002	.001	1.419	3.713	.000
	Ln_Price_Density_3	-1.617E-005	.000	-.621	-2.564	.010
	LICENCE_NUM	1.233	.526	.097	2.345	.019

a. Dependent Variable: Emission

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