I T L S

WORKING PAPER

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What if petrol increased to $10 per litre? Implications on travel behaviour and public transport demand

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TITLE: **What if petrol increased to $10 per litre? Implications on travel behaviour and public transport demand**

ABSTRACT:

Petrol prices are increasing at a formidable rate. In July 2007 unleaded regular petrol in the typical Australian capital city was about $A1.20/litre and 12 months later the price was over $A1.60/litre. Pundits predict that the price will be $A2/litre by the end of 2008, and long-term forecasts by the CSIRO† suggest a price as high as $A8/litre in 2020. Given these recent hikes in petrol prices, we are seeing almost daily commentary on what this will mean for the future of mobility and accessibility. Commentary ranges from fear mongering using analogues from theology, such as 'the war on mobility has finally arrived' and 'the end of western life styles as we know them', through to views that we must not allow this to happen and government must act by reducing fuel excise. Others express elation that finally we have pricing signals that might encourage earlier investment in substitutes that include public transport, more fuel efficient cars as well as lower polluting vehicles. This paper uses TRESIS, an integrated transport, land use and environmental strategy impact simulation program, to assess the influence of higher fuel prices on short run and long run passenger travel activity in Melbourne. We evaluate petrol prices in the range $A2 to $A10 over the period 2009-2017, to establish likely impacts on car use, modal share, greenhouse gas emissions, public transport revenue and consumer surplus.

KEY WORDS: ***Tresis1.1M, systemwide impacts, fuel prices, public transport, vehicle use, CO_2***

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1. Introduction

Traffic congestion, high fuel prices, and crowded public transport are three transport themes that are daily headlines that hit home to all urban populations. Until very recently when fuel prices began increasing at a non-marginal rate (see Figure 1), traffic congestion was attributed as the major cause of the switch from car to public transport in many jurisdictions, creating high levels of overcrowding and congestion on trains and buses. The large increases in fuel prices in 2007[1] are now being suggested as the main reason for reduced car use and increased public transport patronage, with Figure 2 showing the correlation between bus patronage increases and Melbourne fuel prices.

With changing travel behaviour and claims on why this is occurring, the important message is that any market response is likely to be a result of more than one circumstance. We need a framework within which we can better understand the likely system-wide impact of fuel price increases, as measured by a range of outputs that reflect the specific interest of the inquiry.

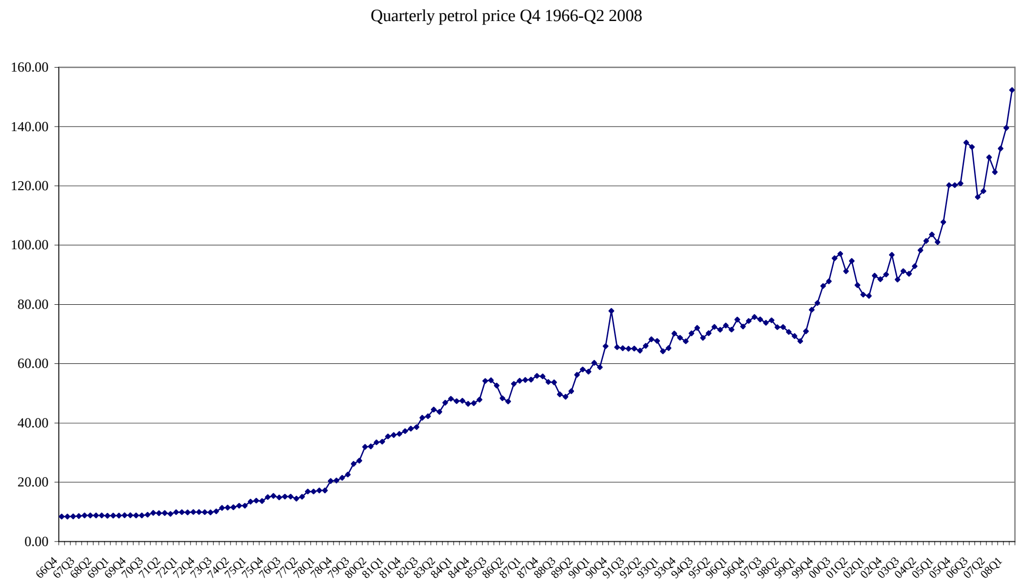

Figure 1: Trend in nominal petrol prices: Q3 1966 to Q2 2008

[1] Typically increasing from around $A1.20 for a litre of petrol at the beginning of 2007, to over $A1.60 in June 2008, with Melbourne unleaded petrol price data shown in Figure 3.

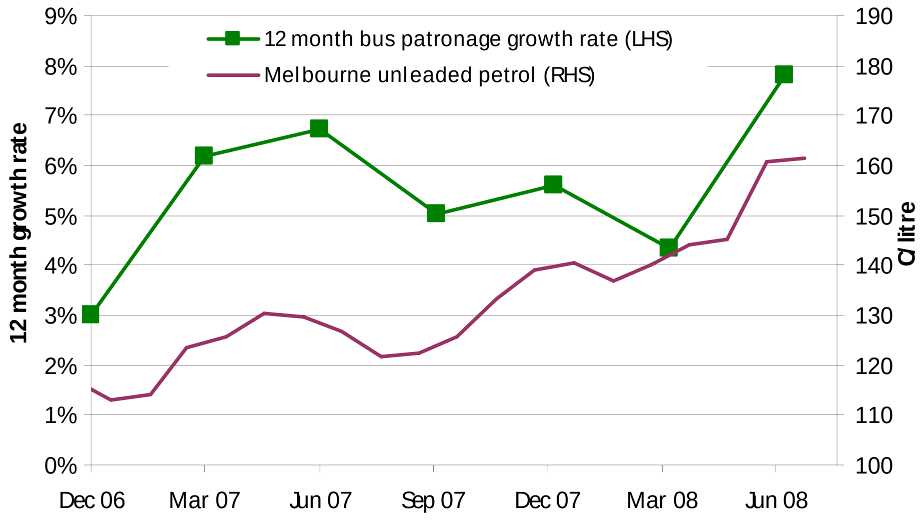

Figure 2: Melbourne bus patronage growth and petrol price increases

TRESIS, an integrated transport, land use and environmental strategy impact simulation program, developed by the Institute of Transport and Logistics Studies (ITLS) at University of Sydney, is one framework developed to evaluate potentially effective instruments that are aimed at a number of policy objectives linked to the triple bottom line – economic efficiency, environmental sustainability and social equity.

The paper is organised as follows. We begin with a brief overview of TRESIS1.1M, followed by a case study in which we apply TRESIS to the Melbourne metropolitan area, to assess the impact of an annual increase in fuel prices for car use of $1 per annum enacted in 2009 up to 2017. We conclude with suggestions for ongoing research efforts.

2. Overview of TRESIS

TRESIS[2] (**Tr**ansportation and **E**nvironment **S**trategy **I**mpact **S**imulator) is designed as a policy advisory tool to evaluate the impact of transport and non-transport policy instruments on urban travel behaviour and the environment with a wide range of performance indicators. The focus is on strategic prioritisation, offering guidance on the directional impact and possible magnitudes of impact of specific mixes of policy instruments on a range of key performance indicators. As an integrated model, TRESIS offers users the ability to analyse and evaluate a variety of land use, transport, and environmental policy strategies or scenarios for urban areas. The results of a base case scenario are used as references to compare with those of the policies and projects to be tested.

The model generates a number of performance indicators to evaluate these effects in terms of economic, social, environmental and energy impacts. The version of TRESIS used herein, called TRESIS1.1M for Melbourne, is an update of the original 1993

[2] Developed since 1995 at the Institute of Transport and Logistics Studies (ITLS), University of Sydney.

TRESIS[3] in terms of socioeconomic and transport network data, and examines strategic level policy options for the Melbourne Metropolitan Area. The base year is 2007 with a forecasting horizon up to 2017. It has integration of land use and transport interaction in each simulation period. The synthetic nature of the model provides a detailed description of the base year of 2007 to be estimated within the model. TRESIS1.1M is structured around seven key systems (see Figure 3). Further technical details are detailed in Hensher (2002) and Bain et al. (2008)

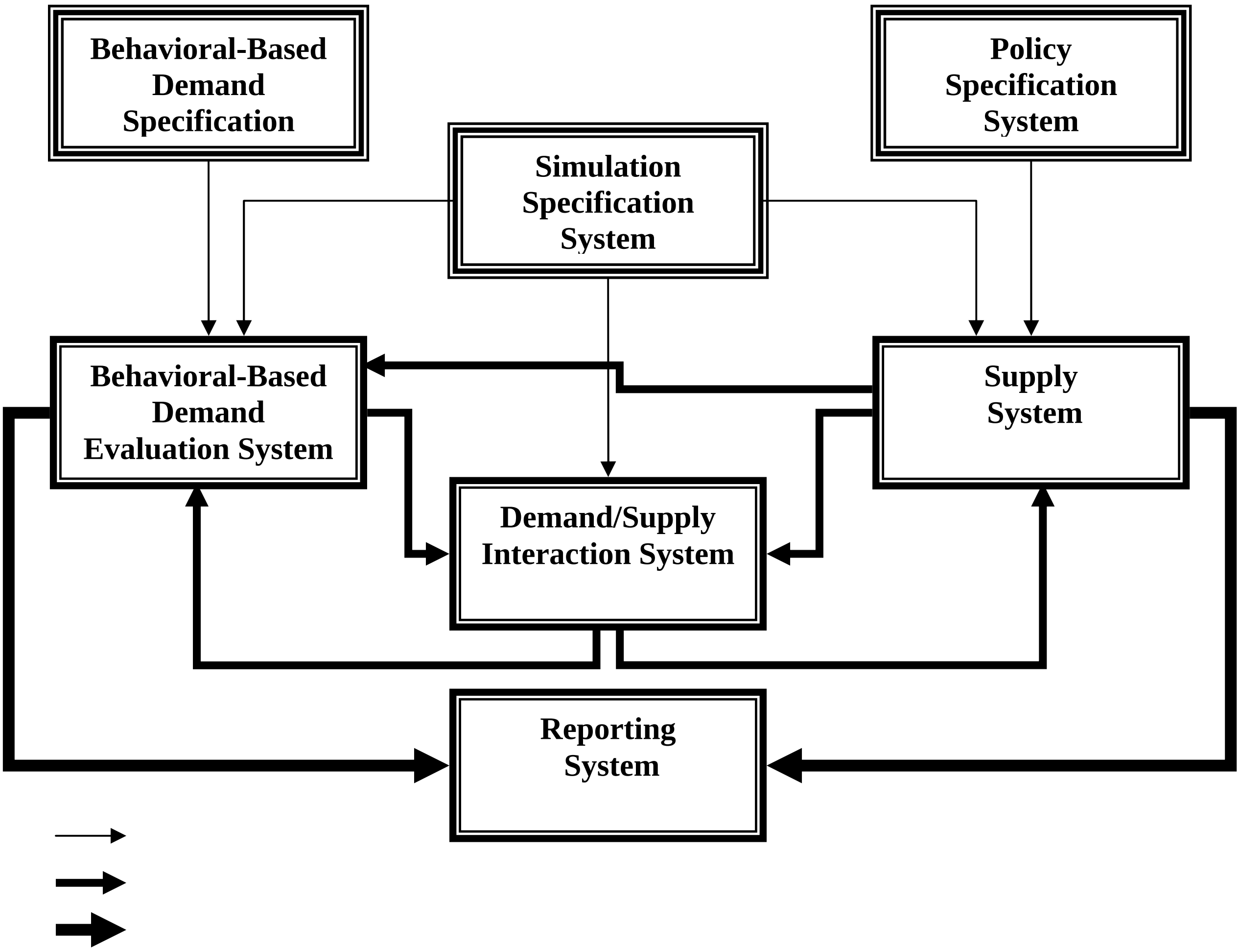

Figure 3: TRESIS1.1M structure

We report aggregate outputs (at a city level). The selection of output indicators of interest is generally determined by the objectives of the study. For example, in an environmental evaluation, greenhouse gas emissions (i.e., CO_2) are an appropriate indicator. In aneconomic analysis, vehicle operating cost and government revenue impacts also provide useful indicators. From a transport planning perspective, we may be interested in indicators such as changes in modal share, total vehicle kilometres and trips between each origin-destination pair. We have selected a range of indicators that

[3] The original version 1.1 of TRESIS (with a 1993 base year) was developed and applied to six Australian cities, namely Canberra, Sydney, Melbourne, Brisbane, Adelaide and Perth (Hensher 2002).

enable us to consider the impact of fuel price increases on efficiency, equity and sustainability. They are summarised in Table 1.

Table 1: List of Selected TRESIS1.1M outputs

Performance Indicators	Description	Units	Note
TCO_2	Total annual carbon dioxide	Kilograms (kg)	Car (includes all passenger automobiles – sedan, wagons, utilities, panel vans, 4WD), based on 2.35kg CO_2 per litre of petrol. The calculation of this output is independent of the carbon tax function. The carbon tax calculates total carbon content which is equal to carbon content rate x fuel consumed (litres). Carbon content rate is set at 0.635775 kg Carbon per litre of petrol
TEUC.MC	Total annual end-use money cost	Dollars ($07)	All person trips, includes for car: op cost, car registration charges, annualised vehicle cost, parking, toll, congestion charge; and public transport fares
TEUC.TTC	Total annual end-use travel time cost	Dollars ($07)	All person trips; with travel time for ride-share for each person in car (converted to $'s). This item also includes all components of time of public transport users
TEMUDTMC	Total annual expected maximum utility from each model system for each of the model components defined - by departure time and mode choice (DTMC) links	Dollars ($07)	Calculation uses full set of 36 (=6Modesx6Times of Days) exp*V functions
TVKM(km)	Total annual passenger vehicle kilometers	Kilometres (km)	Car
VehOpCost	Total annual auto VKM operating cost	Dollars ($07)	Car fuel only.
TPT	Total revenue from public transport use	Dollars ($07)	All PT (all modes, private and public). Fares assumed to remain at $07 levels over 2007-2017
TDA	Modal growth for car drive alone	%	All person trips
TRS	Modal growth for ride share	%	All person trips
Ttrain	Modal growth for train travel	%	All person trips
Tbus	Modal growth for bus travel	%	All person trips
TLrl	Modal growth for light rail travel	%	All person trips
Tbwy	Modal growth for busway use	%	All person trips

<u>Note</u>: A trip = a Person Trip (e.g., 2 person's ride sharing = 2 person trips)

The Vehicle operating cost variable needs special definition given its constituent parts. It comprises:
VehOpCost = [{cityFuel*propCityF + hwyFuel*(1-propCityF)}*0.01] * [tPricePetrol*(1-propnDiesel) + tPriceDiesel*propnDiesel
where:
cityFuel = city cycle fuel efficiency (litres/100 km)
hwyFuel = highway cycle fuel efficiency (litres/100 km)
propCityF = proportion of use which is in the city fuel cycle (default = 0.7)
propnDiesel = proportion of conventional-fuelled vehicles using diesel
tPricePetrol = wpricepetrol + expricepetrol (cents per litre)
wpricepetrol = wholesale price of petrol (cents per litre)
expricepetrol = excise component of price of petrol (cents per litre)
tpricediesel = wpricediesel + expricediesel (cents per litre)
wpricediesel = wholesale price of diesel (cents per litre)
expricediesel = excise component of price of diesel (cents per litre)

The VehOpCost indicator excludes spatial cost strategies such as a toll and a congestion charge. It is strictly related to fuel-based strategies (changes in fuel efficiency, carbon tax, fuel excise). All elements are included in TEUC.MC.

3. Application of TRESIS to fuel price increases for car use

Petrol prices have increased substantially in recent years, with the retail pump price in Melbourne in mid 2008 fluctuating around $A1.55 per litre (given the price of a barrel of crude of about $US140). Media comments in June 2008 are typified by "Economists expect the petrol price to hit $A1.75 dollars a litre next week and $A2.00 by the end of 2008. Motoring organisations agree that prices will jump by at least 10 cents a litre." Such changes pose questions such as how will the price rises impact on public transport patronage and what might they mean for greenhouse gas emissions, over various time horizons. Table 2 summarises the fuel price increases evaluated herein, which are equivalent to $A1 increase per annum after 2008 (in constant 2007 dollars). This range covers all of the speculation in the media and scientific papers.

Table 2: Retail fuel price scenarios ($A/litre) $2007

YEAR	petrol	diesel
2007	$1.25	$1.40
2008	$1.25	$1.40
2009	$2.00	$2.08
2010	$3.00	$3.08
2011	$4.00	$4.08
2012	$5.00	$5.08
2013	$6.00	$6.08
2014	$7.00	$7.08
2015	$8.00	$8.08
2016	$9.00	$9.08
2017	$10.00	$10.08

The year of introduction (i.e. the exogenous shock) starts in January, evaluating a policy annually, summing the impacts over time and reporting the findings for each year. The cost items are calculated in constant dollars ($A2007). TRESIS1.1M provides the results of these selected indicators for the *base case* and *policy case for each application year*, defined as:

- *Base Case*: This is a scenario of "business as usual" in each year. This would be $A1.25 and $A1.40 for petrol and diesel respectively.
- *Policy Case*: A policy is implemented and its impact is evaluated by comparing the output indicators between the base case and policy case.

We report in Table 3, the differences between the base and policy case in each year, selecting three years to report the evidence: 2009, 2013 and 2017.

Table 3: Summary results for fuel price increases

(Policy enacted in 2009 up to 2017, Melbourne)

Indicators	**Increase petrol and diesel prices by $1 pa**			
	Base year 07	2009	2013	2017
AvOpCost #	11.57c/km	59.54%	215.59%	657.35%
Total government public transport revenue	$460m	16.85%	142.75%	226.23%
Average vehicle kms per car	15,140	-5.82%	-15.48%	-18.05%
Total end user cost (TEUC):				
TEUC.MoneyC @	$5.18bn	27.86%	157.73%	260.06%
TEUC.TimeC @	$3.93bn	-5.33%	-33.78%	-44.93%
Total end user cost per car kilometre	$0.212	36.83%	223.61%	382.73%
Consumer surplus		-32.1%	-67.13%	-76.92%
*Commuter Mode growth:**	$8.46bn			
Drive alone	77.1%	-3.92%	-35.06%	-57.42%
Ride share	5.2%	-4.18%	-36.54%	-58.93%
Train	9.5%	18.66%	162.28%	254.44%
Bus	2.3%	18.56%	163.09%	260.41%
Light Rail	4.1%	8.67%	76.64%	133.74%
Busway	2.1%	10.58%	62.37%	109.97%
Greenhouse gas emissions:				
TCO_2 (kg)	6.049bn	-6.76%	-22.64%	-29.62%
CO_2 per car vehicle kilometre	0.2477	-0.30%	-2.86%	-5.64%
Passenger vehicle kms	24.42bn	-6.48%	-20.36%	-25.41%

*These percentages are growth in patronage, noting that bus, tram (light rail) and train are off a very small base.
+ The base is so low (i.e., 0.655%) that this distorts the percentage increase. # vehicle operating cost per km is car fuel only. @ Adjustments in time and money cost are the main set of influences on mode and departure choice. Time cost plus money cost defines generalised cost.

We evaluated prices as high as $A2 by early 2009. This is equivalent to a 59.54 percent increase in car operating cost per kilometre, close to 7c/km. This results in a forecast 6.48 percent reduction in overall vehicle kilometres, which has very positive impacts on traffic congestion[4]. By 2017, the progressive $A1 annual increase in fuel costs is forecast to cut annual passenger vehicle kilometers by one quarter (25.412%).

The $2/litre price for petrol in 2009 delivers Melbourne a 6.76 percent reduction in car CO_2 emissions. By 2017, the progressive annual fuel price increase is projected to cut CO_2 emissions from Melbourne's cars by almost 30% in that year.

Australia has announced a target to reduce greenhouse gas emissions by 60% on 2000 levels by 2050. Interim targets have not been set at this time. However, the European Union has indicated that its members would be prepared to unilaterally cut emissions by 20% below 1990 levels by 2020 or to cut emissions by 30% in the context of a suitable international agreement post-2012 (provided other developed countries join in).

The Australian Department of Climate Change has projected that Australian road transport emissions in 2020 will exceed 1990 levels by 67% on a business as usual basis

[4] A news item on June 4 2007 in the USA commented on very noticeable reductions in traffic delays in Los Angeles, attributed in part of the $US cost per gallon of gas. Traffic volumes on the road network in Melbourne typically fall by about this magnitude during school holiday periods, with substantial reductions in congestion.

but allowing for the emission-reducing impact of a number of established measures, such as travel demand management initiatives, fuel economy improvements, greater use of biofuels and increased conversion to gas (DCC 2008). Given that the transport sector is Australia's third largest source of greenhouse gas emissions, accounting for about 14% of total emissions, major emission reductions from the sector will be required in any national emission reduction solution. Against this background the effect of a rise in petrol prices to $A10 would be to contribute very usefully to any likely 2020 national emission reduction target.[5][6] However, much would remain to be done, given the underlying growth trend in emissions. For example, if emissions from all road transport were to be reduced by 25% in 2020, this alone would only serve to bring projected transport sector emissions at that year back to about 2005 levels.

An emissions trading scheme will play an important role in putting downwards pressure on Australian greenhouse gas emissions in coming years. This analysis suggests that complementary measures[7] are likely to be essential to deliver large emission cuts. The major reason for this is that the range of carbon prices typically canvassed in an Australian ETS is $10-60/t CO_2-e, which translates to between about 3-16 cents a litre increase in fuel costs, which is very much less than the price changes considered in this paper.

The continued increase in petrol prices built into the analysis is projected to produce a very substantial growth in public transport use, as people shift to less expensive modes. Train and bus patronage are each projected to increase by about 250% by 2017 and tram patronage by 134%. These large projected patronage increases are problematic where public transport capacity is already stretched (as is the case in Melbourne). Substantial infrastructure and service investment is needed to provide the additional capacity to service this growth.

The challenge is clear – substantial reductions in car use will not be achieved where public transport is unable to deliver acceptable alternative services. The evidence herein suggests massive opportunities for public transport, even if petrol price increases fall well short of the high figures projected for 2017. If substantially improved public transport services are not provided in the face of increasing fuel costs (and of the need for governments to more broadly respond to climate change pressures, which in the transport sector are mainly linked to motor vehicle use), the result will be travelers adopting coping strategies, centred around car use and relocation activity (including revised work practices such as telecommuting and even more 'peak' spreading).

Public transport fare revenues are projected to increase strongly with patronage growth. Contractual conditions in place for public transport service delivery need to ensure that this revenue can be used, inter alia, to help improve the service levels that will be required to cater for projected patronage growth. For example, revenue could be used to contribute towards fast tracking of bus rapid transit systems, such as those provided in Brisbane, Curitiba and Bogota (see Hensher and Golob 2008).

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[5] Assuming that similar impacts would be felt in other capital cities as are projected for Melbourne and that regional car travel, and truck travel in regional and metropolitan areas, would also be reduced.

[6] Interestingly, peak congestion costs in Melbourne are of the order of $1/km, or higher. At 10L/100 kms fuel use, this translates to a cost of about $10/L, our 2017 assumed fuel cost, if the cost was to be recovered through a fuel levy (an imperfect device for congestion charging).

[7] Such as high occupancy vehicle lanes, improved cycling paths and, longer term, more compact urban settlement patterns.

Not surprisingly, the assumed increase in petrol prices is associated with a very substantial reduction in traveler welfare or "consumers' surplus" (the difference between the expected value derived by travellers from their travel and the cost to them of such travel). For example, in 2009 there is a projected aggregate net consumer surplus loss of $5.49bn, due to fuel prices rising to $A2/litre but partly offset by reductions in traffic congestion (given an 8.1 percent reduction if car trips = drive alone plus ride share in Table 3), and gains in travel times (i.e. a time cost reduction of 5.33 percent or $259m) for those who continue to pay the high fuel prices. These calculations allow for the change in generalized cost (money and time) associated with modal switching and changes in the amount of trip activity. By 2017, the reduction in consumers' surplus is forecast to be a substantial 76.92%. The analysis undertaken herein has not factored in manufacturer responses in terms of significant fuel efficiency gains offered in new technology, including alternative fuels. However, TRESIS1.1M does allow for vehicle class substitution, driven by fuel price increases, with noticeable downsizing to partly compensate for higher fuel prices.

4. Conclusions

This paper has investigated the impact of significant and progressive fuel price increases on passenger travel in Melbourne over the period 2009 to 2017. The analysis raises a number of policy issues that must be tackled in the event of significant and continuing price rises. The paper has chosen to focus on the impacts on consumer welfare, use of cars and public transport and on greenhouse gas emissions.

As expected, substantially increasing petrol prices are projected to lead to large reductions in consumers' surplus or welfare. An important positive outcome is a significant contribution towards future greenhouse gas emission reduction targets, primarily achieved through a growth in public transport use and reduction in car use. However, the forecast reductions in emissions, even under the extreme price assumptions adopted in this paper, are well short of what is likely to be required to meet future emission reduction targets. Complementary measures (to an ETS) must be an important element in pursuing future GHG emission reductions and should form a vital part of all integrated transport strategies.

The paper has shown that price can play an important role in cutting petrol use. However, if fuel prices rise anything like the magnitude canvassed in the paper, due to market forces (e.g. demand and supply of oil), travellers will suffer a very considerable loss in welfare (consumers' surplus). If prices were to rise because governments choose to implement policy measures such as congestion charging, the aggregate welfare losses for travellers will be reduced because governments will have a substantial pool of revenue available to use to improve travel options.

The analysis has shown that large petrol price increases will drive strong demand for public transport use. Recent price increases have caught governments around Australia short in terms of available public transport capacity. Substantial capacity additions are likely to be required to respond to climate change and as a risk management strategy against possible peak oil.

It is important to recognise that forecasts based on each policy instrument carry varying degrees of forecast uncertainty, in part linked to the specification of TRESIS1.1M, but also markedly influenced by the ability of stakeholders to actually implement the specific policies at the levels assessed. The biggest challenge society will face in the event of high fuel prices is the absence of adequate public transport capacity.

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