WORKING PAPER

ITLS-WP-13-03

Sunday drive: Review of automobile ownership, societal and environmental impacts and behavioural change.

By
Matthew J. Beck

February 2013

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-13-03

TITLE: **Sunday drive: Review of automobile ownership, societal and environmental impacts and behavioural change.**

ABSTRACT: The automobile is a pervasive component of modern life; it has played a crucial role in shaping the society in which we live and the way in which we behave and interact with those around us. This paper provides an overview of the motor vehicle; tracing the origins of the automobile, how it helped shaped many aspects of societal and urban development and the psychological impacts on society. It also reviews studies that have explored the driving factors of vehicle ownership and choice at a disaggregate level and examines the literature that addresses the environmental impacts of the motor vehicle. The conclusion is drawn that there is perhaps no single product that has had as big an impact on modern society as the motor vehicle, an impact that is unlikely to wane. As such, the automobile will continue to be fertile subject matter for researchers from many disciplines and for in policy who must make plans in the presence of the motor vehicle.

KEY WORDS: ***Automobile, motor vehicle, ownership, choice, environment, society, planning.***

AUTHOR: **Beck**

CONTACT:

INSTITUTE of TRANSPORT and LOGISTICS STUDIES (C13)
The Australian Key Centre in Transport and Logistics Management

The University of Sydney NSW 2006 Australia

Telephone: +612 9114 1824
Facsimile: +612 9114 1722
E-mail: business.itlsinfo@sydney.edu.au
Internet: http://sydney.edu.au/business/itls

DATE: February 2013

1. Introduction

Roland Barthes (1957) wrote that:

> *"Cars today are almost the exact equivalent of the great Gothic cathedrals. The supreme creation of an era, conceived with passion by unknown artists, and consumed in image if not in usage by a whole population which appropriates them as a purely magical object."*

More than half a century later this sentiment still resounds. Since the development of the first mass produced motor vehicle in 1908, the automobile has played a significant role in many societal and economic developments over the past 100 years. Arguably, no single commercial product has had a larger effect on our way of life. Not only a mode of transportation, the motor vehicle plays a defining role in how we interact with our environment, influences the design and shape of our cities, affects both social interactions and inclusiveness, and the fuel on which automobiles rely forms a large part of domestic and international political discourse.

In response to the thrall in which the motor vehicle holds society, research on motor vehicles has interested those in environmental studies, transportation, or sociologists interested in understanding the motor vehicle phenomenon. This paper draws together a number of streams of research to provide the reader with an overview of motor vehicle ownership and use. The paper is structured as follows; the first section discusses the role the automobile has played in shaping the development of modern society and the integral part it now plays in the human psyche; the second section then examines the studies that have researched consumer choice with respect to motor vehicles; and the final section examines vehicle choice, but with reference to a more recent stream of research that examines the purchasing of alternative fuelled, more environmentally friendly, automobiles.

2. The motor vehicle and society

2.1 A brief history

Focusing on the United States, the origin of the first mass produced automobile, the first cars were unaffordable for the majority of people. The average price of an automobile in 1900 was in excess of US$ 2,000, compared to the average yearly income of US$ 438 (Derks 2009). In 2008 the average yearly income was US$ 26,964 (DeNavas-Walt et al. 2009) with the average price of an automobile US$ 28,350 (NADA 2009). The falling real price of the car has meant a substantial growth in sales such that total yearly sales have exceeded ten million units for each of the past 15 years (NADA 2009). The primary reason for the decreasing real price of motor vehicles was the advent of select mass production techniques that were pioneered in the automobile industry. Introduced by Henry Ford in 1908, the original Model T Ford was essentially the first mass produced consumable and this production technique allowed for sharply reduced costs via improved economies of scale. The success of the assembly line system used in the Ford plant permeated to other production processes and dramatically changed how products were made in many industries. The first Model T sold for $850US, as a result of the mass production process, but by 1926 it was priced as low as US$ 240, the equivalent of US$ 122 in 1908 (Williamson, 2010). Such price reductions made car ownership attainable for more than just the rich, and the economic boom of the 1920s gave rise to the two largest consumable objects of the 20th century: the family home and the automobile.

During this period the rapid growth of the car market resulted in increased numbers of used cars being available, reducing profitability for vehicle manufacturers, thusly incentivising new production methods designed increase new car sales. General Motors, in a departure from

Ford's single model production philosophy, began selling cars with a similar basic frame but with different bodies and different features. Whilst earlier motor vehicles were largely utilitarian, the diversification approach devised by General Motors meant that the motor vehicle had begun to appeal to the aesthetic consciousness. The emergence of style or appearance as a competitive factor soon became a fundamental requirement in the industry, so much so that during this period Harley Earl, a leading designer at General Motors, argued that his job was to "hasten obsolescence" (Miles 1998).

The Great Depression of the 1930's, however, saw all auto companies radically cut back on spending and production. Between 1920 and 1933, one third of general US manufacturing establishments closed, with one out of every two motor vehicle plants shutting down (Bresnahan and Raff 1991). With the occurrence of the Second World War, much manufacturing was reoriented towards military production. However, post-war Keynesian economic policies provided major support for private family home ownership, in part through mortgage guarantees for returning troops, which was complemented by subsidisation for suburban development. This lifestyle shift resulted in larger demand for the automobile as in the lower density suburban environment, relatively poorly served by public transport, the car was a necessity for many; however the relationship was symbiotic in as much as the car also facilitated the continuing growth in suburban living. Growth of motor vehicle ownership escalated and by the early 1950's most American families owned a car. However, this meant that the market was becoming heavily saturated and the industry started facing falling unit demand. At the same time working people's discretionary spending was rising and in light of this, manufacturers moved to increase each car's size and array of accessories as well as the frequency at which they introduced new models, in order to increase sales volumes. During this period, the ownership of a car became a highly personal choice based just as much, if not more, on form than on function.

By the 1960's though, consumer preferences in America had started to change. The Wall Street Journal commented that there was a "growing rebellion against cars…the novelty and status of car ownership are long gone. So they look at their auto as an appliance" (Gartman 1994). With a more functional mindset, consumer demand for smaller more functional vehicles grew and as American manufacturers persisted with their large car strategy, European and Japanese imports increased. The oil crisis of the 1970's further shifted public opinion; the etymology of the term "gas guzzler" points to an origin during this period. While increasingly more compact cars came to market in response the economic boom of the 1980's saw the genesis of a new form of motor vehicle, the sports utility. This new vehicle came to prominence in the 1990's and early 2000's and became the fastest growing segment of the auto industry. These vehicles were more expensive than small cars, thus had greater profit margins, and also required more fuel per mile to operate and produced greater amounts of pollutants. They are also driven further annually than are automobiles of the same vintage, exacerbating fuel-use and emission problems (Davies and Truett 2000).

In more recent years, the automotive industry has been confronted with unstable fuel prices, for example in 2000 the price of oil was US$ 33 per barrel, in 2004 the figure was US$ 40 and in 2005 it had risen to US$ 55 per barrel (Small and Van Dender 2007). These changes affected the automotive industry via two channels: shifting new auto purchases towards more fuel-efficient vehicles, and speeding the scrapping of older, less fuel-efficient used vehicles (Li et al. 2009). Public demand for more fuel efficient vehicles has grown, with the European market experiencing growth in the sales of small diesel engine vehicles, and Japanese manufacturers developing a small, but increasing, range of hybrid vehicles. There is also increased interest in the use of biofuels as an alternative fuel source, particularly ethanol blends. The tension on vehicle ownership placed by increasing oil prices is also compounded with increasing focus on the role that vehicle emissions play in the environment. Given these pressures it would not be unreasonable to expect a fundamental shift in either vehicle demand or technology in the near future.

2.2 Phenomenology and psychology

The influence of the motor vehicle extends beyond a purely utilitarian purpose. Given the range of available models and makes, automobile purchase is highly subjective and is an experience in which many owners responded with emotion, or attach nostalgia to the vehicles they have owned. Social commentary has focused largely on the negative impact of motor vehicle use on the environment, health and urban design. However, a small number of sociologists have explored the cultural and emotional constituents of car ownership, for example Gartman (2004) postulates three cultural ages of the automobile. The first is the age of class distinction, where in the early years of automobile production the car was a status symbol of the bourgeoisie. While the mass-production of the 1920's made cars more widely available the nature of the production process only enforced this distinction; mass produced cars reflecting mundane concerns for function and safety whereas the luxury car was hand made with superior engineering and a greater range of aesthetic differences. As production became more advanced and incomes rose, the vehicle entered the second age, the era of mass individuality. By the late 1920's firms were offering a large variety of models differentiated by aesthetics and accessories, with the General Motors mission being to produce a car for "every purse, purpose and person." Gender differences became less profound, with more women driving cars. In this period the car became an expression of individual freedom and an escape from mass-produced society via taking to the roads. Finally, the automobile entered a post-Fordist age, the era of sub-cultural differences. In the 1960's the number and types of vehicles available increased dramatically, with classes such as compacts, subcompacts, medium, large, sports, and luxury. These artificial differences obscured real class differences and cars became a representation of lifestyle choices and automakers sold brands and identities rather than simple cars.

Consumers often imbue motor vehicles with meaning. Bao and Sweeney (2009) find that brand personalities are evident for automobiles, having specific interpersonal characteristics. For example, they find that a BMW might be described as relatively ruthless and dominant and the Toyota Echo is viewed as relatively timid or forceless. These symbolic and affective influences have also been examined in terms of car usage behaviour. Steg (2005) found that the average commuting car use was significantly related to symbolic and affective motives (such as prestige, power and joy of driving) and not related to instrumental factors (such as carrying capacity, protection against weather and safety). Sheller (2004) discusses the emotions of automobile ownership and use, stating that owners have feelings for their cars, emotions evoked by the noise and sound of the engine, or the thrill of acceleration or the sights from the windows, and that car takes part in the ego-formation of the driver. Further, cars bring about caring and kinship through their role in social inclusion and empowerment and have distinct national identities and can also be a source of nationalistic emotions.

3. Ownership and choice

Given that the automobile has a significant role in the development of modern society and will continue to shape societal relations into the future, vehicle ownership has long been an area of research for those in the field of marketing, transportation, and the environment. Early studies of vehicle demand focused on aggregate determinants of ownership such as prices, fuel efficiencies and incomes, usually employing time series data. One of the earlier studies of automobile ownership by Ben-Akiva and Lerman (1974) considered six broad factors as influences on the number of automobiles owned: features of the work trip such as time and cost; socio-economic characteristics such as education and income; locational factors like insurance and parking; vehicle costs such as taxes and maintenance; housing attributes such as garages; and special aspects such as shops and schools. These techniques are still very much in use today in attempting to determine aggregate automobile ownership, for example a recent model for car ownership in the Netherlands using the consumer price index, income, age, household size and number of workers in the household as determinants of ownership (MuConsult 2005).

A comprehensive aggregate model was developed by Berry, Levinsohn and Pakes (1995) in which both the parameters for consumer demand and producer prices were modelled. This model, which has become known as the BLP model, modelled vehicle choice as a function of horsepower to weight, air conditioning, miles per dollar, size and price. The study that consumers of small fuel efficient vehicles are very elastic with respect to changes in improvements in miles achieved per dollar spent, but consumers of larger cars and more expensive vehicles had a disutility for these improvements, with demand falling as a response. Berry, Levinsohn and Pakes (2004) built on this model by including household characteristics in estimation as well as the second choice of households, finding that the use of the second choice in conjunction with the first choice allowed for better modelling of substitution patterns among consumers.

Bunch (2000) brings together a number of studies to primarily explore initial attempts to model vehicle choice via the multinomial logit and how methodological advances such as the nested and mixed logit have increased the behavioural realism of these models. As part of this overview, factors such as household characteristics (e.g., size, ages, occupations, and income), location of the home, configuration of relevant school, work and shopping locations, the alternative transport services, vehicle availability, operating characteristics and costs, are shown to be significant in determining the type and number of vehicles purchased. Focusing more on specific characteristics of the automobile, vehicle type choice is typically estimated on individual or household level data where the choice of automobile is based on the most attractive bundle or combination of vehicle attributes, conditioned by household and socio-demographic characteristics. These studies have a range of applications though typically they seek to investigate the key determinants of choice of a specific type or size of vehicle, or explore the role that individual characteristics such as attitudes play in vehicle selection, or examine how a specific new feature or attribute of a vehicle may influence demand. However, other factors also influence automobile choice. Table 1 provides a summary of the vehicle and household characteristics used in the literature reviewed in this paper.

Table 1: Factors influencing vehicle type choice – compiled from the reviewed literature

Vehicle Attributes	Household Factors
Price	Personal income
Weight	Household income
Vehicle Age	Age
Number of seats	Number of household members
Acceleration	Number of vehicles owned
Luggage space	Information search costs
Engine size	Gender
Brand	Education
Horsepower	Transit accessibility
Turning radius	Attitudes (travel & environment)
Number of models/makes	Personality traits
Airbags	

In an exploration of the role of attitudes and lifestyles in vehicle choice Choo and Mokhtarian (2004) examine factors influencing choice of nine types of vehicles (small, compact, mid-sized, large, luxury, sports, minivan, pickup, and SUV) and find that travel factors (dislike of travel and pro high density living), personality types (organisers and calm individuals), life style factors (frustrated, workaholics and status seekers), perceptions of mobility over short and long distances, and socio-demographic factors (age, education, gender, employment, age of

household members and income) all play a significant role in determining vehicle type choice, with each vehicle class able to be uniquely profiled through these characteristics. Koppel et al. (2008) investigate the role that safety attributes play in vehicle choice, finding most participants equated vehicle safety with the presence of specific vehicle safety features or technologies rather than vehicle crash safety/test results or crashworthiness and the key parameters associated with ranking 'vehicle safety' as the most important purchasing a new vehicle purchase are: gender and education level, age, drivers' concern about crash involvement, first vehicle purchase, annual driving distance, person for whom the vehicle was purchased, and traffic infringement history.

As opposed to the usual aim of determining what might increase demand for a particular vehicle type, Train and Winston (2007) take a counter approach, investigating changes in buyer behaviour in the US market that has led to declining market shares of domestic brands. Interestingly they found that brand loyalty towards US manufacturers had improved, contradicting the perceived rationale for the decline. Instead, they find that the vehicle offerings and attributes such as price, fuel consumption and horsepower are responsible for the decline, not subtle attributes such as styling, extra options or unobserved tastes. This result has important implications for those interested in the study of motor vehicles as it indicates that the functional aspects of a motor vehicle potentially play just as crucial a role in vehicle choice as the intangible factors.

The role of exogenous factors on vehicle choice has also been examined. Fang (2008) investigates the role that residential density has on household vehicle type choice, finding that increasing residential density has no effect on the choice and use of vehicle type and size, only significantly reducing households' SUV/truck holdings and utilization, albeit in an economically insignificant way. Similarly, Potoglou (2008) explores the role of the built environment on vehicle type choice, incorporating proximity and urban form measures derived from high-resolution spatial data and geographic information systems technology. Estimates from discrete choice models of households' latest vehicle-type choice suggest that preferences for less fuel-efficient vehicles such as pickups and SUVs are marginally affected by the diversity of land-uses at the place of residence, such as distance to entertainment venues and number of retail stores, after controlling for travel to work attitudes and socio-demographic characteristics.

Hensher et al. (2008) used the household purchase of an automobile to examine the role of preference revision and negotiation in the choice of a jointly consumed item. This paper represents a break from the typical approach of examining group choice where a proxy respondent is sampled to respond on behalf of the household. Using the motor vehicle, Beck et al. (2011) examined the accuracy of such proxy responses and found some evidence that this sampling method can approximate the responses of a household unit. Lastly, Hensher et al. (2011) find that household vehicle choices are more stochastic than individuals.

4. The motor vehicle and the environment

The automobile, as a major emitter of both local air pollutants such as lead and carbon monoxide (Hensher and Button 2003) and CO_2, continues to come under increasing scrutiny. In Australia motor vehicles contribute 41.9 million tonnes of carbon dioxide or equivalent greenhouse gases, approximately eight per cent of total national emissions in 2007. In 2006 transport contributed approximately 23 per cent of total CO_2 emissions (857,583 gigagrams) within the EU-15, with passenger cars accounting for approximately 12 per cent of total CO_2 emissions an influence cited as one of the main reasons for increases in CO_2 emissions between 1990 and 2006 (EEA, 2008).

Strategies to mitigate vehicle emissions and improve air quality by reducing fuel consumption and developing a market for cleaner motor vehicles can be grouped into two broad initiatives; clean car benchmarks, and cleaner vehicle fleets. Clean car benchmarks may be achieved via

economic incentives for vehicle manufacturers to improve vehicle efficiency whilst the creation of a cleaner vehicle fleet can be driven by incentives for the consumer to purchase cleaner vehicles. Though the government may induce manufacturers directly through policies such as mandatory fuel efficiency standards or government fleet purchase decisions, this paper is a survey of private motor vehicle purchasing behaviour and thus review studies that focus on the consumer.

4.1 Alternative vehicles and fuels

Perhaps the earliest work on alternative fuelled vehicle choice emerged from the California study into demand for clean fuelled vehicles. Train (1986) examined electric vehicle demand as a part of his personal vehicle energy demand model. In response to air quality concerns Bunch et al. (1993) employ stated preference techniques to examine demand for clean-fuel vehicles as a function of attributes that distinguish these vehicles from conventional fuelled vehicles. Using the attributes of price, fuel costs, vehicle range, availability of fuel, multi-fuel capabilities and emission reductions, results found that range between refuelling is an important attribute along with cost, but the probability of choosing alternative fuel is also affected by emissions levels which can compensate for fuel costs. Interestingly, subsequent trial experiments with zero emission vehicles that occurred in 1998 showed that although households could use an electric vehicle for most of their trips, the desired range of 100 miles was still double the average daily driving distance (Golob and Gould 1998, Hensher and Greene 2001).

Using the same data Kavalec (1996) uses a nested logit framework to simulate vehicle ownership decisions, where households are choosing the number of vehicles that will be held in a given time period along with the class/vintage choice or choice combination. Brownstone et al. (1996) develop a dynamic transactions choice model for forecasting demand for alternative fuel vehicles using the Californian data. The primary interest of the paper is forecasting the choice of hypothetical alternatively fuelled vehicles conditional on the vehicles currently held by the households, with a major goal being to improve the quality of forecasts by focusing on vehicle transactions rather than vehicle holdings thus allowing for the diffusion of new alternative-fuel vehicles to be forecasted. Using this model the authors forecasted median shares for gasoline, methanol, compressed natural gas and electric vehicles as 60.9, 18.3, 17.2 and 3.6 per cent.

Using the same data, Brownstone and Train (1999) provide one of the first applications of the mixed multinomial logit model.[1] The authors find significant error components with respect to vehicle size and fuel type, which results in more realistic substitution patterns. For instance, in the situation where a small electric car is introduced to a base situation consisting of gas cars that range in size from small to large, the models developed in the paper show that the electric car will draw more proportionately from smaller gasoline cars than from larger gasoline cars. If a large methanol car is added to the small electric and various sizes of gas cars, the models in the paper predict disproportionate switching, with greater switching from the larger gas cars than the smaller gas cars, and with greater switching from the gas cars than the electric car. The later difference is due to the fact that the error component for methanol and gas is the same, indicating a similarity in households' views of these two types of fuel (relative to electric) which relate to similar perceptions of refuelling. Extending the application of the mixed logit modelling framework, Brownstone et al. (2000) argue that the mixed logit model is superior to

[1] Many choice modelling methodologies are subject to the restrictive independence from irrelevant alternatives (IIA) property. Using an example from this paper, a logit model predicts that, among households with the same observed characteristics, an electric vehicle will draw the same proportion of households from large luxury gas cars as from small gas cars. However, if the electric car is similar in size to a subcompact gas car, one might expect the electric car to draw disproportionately from different classes of vehicles, with, for example, households who would have chosen a subcompact gas car switching more readily to the electric car than households who would have chosen a large gas car. Consequently the IIA property imposes a particular substitution pattern rather than allowing the data analysis to find and reflect whatever substitution pattern actually occurs. The mixed logit represents a model form that overcomes this restriction.

the multinomial logit model in that it fits the data more accurately and shows large amounts of heterogeneity in respondents' preferences for alternative fuel vehicles.

Golob et al. (1997) examine commercial fleet demand for alternative-fuel vehicles from 2000 fleet sites in California. They mainly investigate the preference trade-offs for existing and alternative fuel types and other vehicle attributes among fleet managers. The attributes are similar to those used in the personal vehicle purchasing study, including capital cost, range, operating cost, refuelling availability and emission levels. The results showed that there were major differences in preferences for fuel types among fleet market segments. The availability (density) of off-site alternative fuel stations was important to fleet operators, indicating that fleets are willing to trade off more fuel infrastructure for changes in other attributes, for example increased capital or operating costs, or more limited vehicle range. Public fleets (local and county government) were the most sensitive to the capital cost of new vehicles and, along with schools, are the only fleet sector where reduced tailpipe emission levels are a significant predictor of vehicle choice. Fleet operators in the private sector were found to base their vehicle selection less on environmental concerns than on practical operational needs.

Using data from the 2008-09 California Vehicle Survey, Hess et al. (2009) explore the role of seven fuel types (standard gasoline, flexfuel/E85, clean diesel, compressed natural gas, hybrid-electric, plug-in hybrid-electric and full electric) along with different incentives (carpool lane access, free parking, tax credits, reduced tolls and reduced purchase prices) and level-of-service attributes such as age, cost, fuel consumption, fuel availability, refuelling time and acceleration. They found that the impact of the level-of-service attributes were as expected; better acceleration, longer range, better fuel efficiency and improved fuel availability all positively impacted on utility and all cost components decreased utility, though the impact was moderated as income increased. They find that higher incentives would be needed to induce the purchase of compressed natural gas and full electric vehicles. From a methodological perspective, the authors also find significant improvement in model fits and estimated substitution patterns through the use of a cross nested logit due to the ability of this model to jointly capture correlations between fuel types and between classes of vehicles.

While most of the work on alternative fuelled vehicles is largely based in the United States, a number of researchers have investigated their acceptability in differing countries. In Norway, Dagsvik et al. (2002) found that alternative fuel vehicles appear to be fully competitive compared with conventional gasoline vehicles, provided that a suitable infrastructure for maintenance and refuelling exists, and that men are more reserved towards this technology than women. Similar to the US context, results also indicated that unless the driving range for electric vehicles is increased substantially this technology will not be fully competitive. Potoglou and Kanaroglou (2007) examined the factors that are most likely to influence households' choice for cleaner vehicles in a Canadian context where choice alternatives included a conventional gasoline, a hybrid and an alternative fuelled vehicle. They found that reduced monetary costs, purchase tax relief and low emission rates would encourage households to adopt a cleaner vehicle. On the other hand, incentives such as free parking and permission to drive on high occupancy vehicle lanes with one person in the car were not significant. Furthermore, limited fuel availability is a concern when households considered the adoption of an alternative fuelled vehicle.

Hensher and Greene (2001) study choice behaviour of single vehicle households in the Australian context, examining choice between conventional, electric and LPG/CNG automobiles. Aside from fuel type, other attributes considered were the size of the vehicle, the price of the vehicle (varied by age in order to represent the potential for second hand vehicle purchasing), cost of registration, fuel cost per 500 kilometres, range of vehicle, acceleration and boot size. The authors find that vehicle price is significant across all fuel types, however in the case of electric and alternative fuelled vehicles, boot space is not significant and that vehicle range limitations on these vehicles has a significant impact on the choice between conventional and non-conventional fuelled vehicles. Acceleration on an electric vehicle that is considerable

slower than conventional engines has a strong negative influence on choice and, somewhat unexpectedly, medium and large electric vehicles are preferred to small electric cars. The authors also find that the consumer is willing to pay between AU$ 2,000 and AU$ 3,000 extra to for a non-conventional fuelled vehicle that has a range similar to that of a conventional automobile.

What is evident in the review of the literature is conditions exist under which the uptake of alternatively fuelled vehicles would be favourable, however research in this area has been occurring for in excess of two decades yet very few alternative fuelled vehicles have been brought to market; the most of these being petrol electric hybrids. It would seem that a wider range of incentives (or disincentives) may be needed if the promise of alternate technology is to be brought to bear.

4.2 Environmental incentives

In examining various incentives used to encourage the consumer to purchase more environmentally friendly automobiles Potoglou and Kanaroglou (2007) explored the selection of hybrid and alternatively fuelled vehicles in response to the sustainable development strategy of the Canadian government. Policies included elimination of vehicle sales tax, free parking and permission to drive on high occupancy vehicle (HOV) lanes with one passenger in the vehicle. They found that the only incentive based attribute to have a positive impact on cleaner vehicle choice was purchase tax relief. Using the similar types of incentives Hess et al. (2009) found a similar result in the Californian context in that only tax credits were significant.

Martin (2009) evaluates the effectiveness of hybrid tax credits and gasoline taxes in reducing greenhouse gas emissions, with simulations suggesting hybrid tax credits save an average 1.5 million metric tons of greenhouse gas emissions and were more effective than a doubling of the gasoline tax in shifting the new purchases towards more fuel efficient vehicles. Additional modelling examining consumer willingness to pay for fuel cost reduction found an average willingness to pay of US$ 522 in purchase price per one cent reduction in fuel cost per mile, indicating that some buyers will pay more for fuel economy than they save in fuel cost expenses over the life span of their automobiles.

The US Federal Government provided tax deductions of US$ 2000 for purchasers of qualifying hybrids, which was changed to a tax credit in 2006. Additional to the Federal incentive, several state governments offer additional incentives. Colorado offers credits of between US$ 2500 and US$ 6000 for qualifying vehicles, while several states offer incentives upwards of US$ 1500, while other states such as California, New York, Florida and Utah offer waivers for access to HOV lanes. Diamond (2009) uses registration data to examine the impact of these government incentive policies on the adoption of existing hybrid electric vehicles (HEVs) finding that, overall, incentives in the form of sales or excise tax waivers (i.e., immediate monetary benefits) have more impact than tax rebates or credits (i.e., longer term monetary benefits). The strongest influence, however, was found to be the impact of gasoline prices. The author hypothesises that the increasing petrol prices experienced worldwide in 2008 appears to have prompted significant behavioural change in driving habits and the purchase of fuel efficient vehicles.

Gallagher and Muehlegger (2010) also explore how hybrid buyers respond to different types of government incentives over the period 2000 to 2006 by examining state-level sales data for hybrid models available during that time. Their analysis suggests that a sales tax waiver (with a mean value of US$ 1037) is associated with over three times the effect of an income tax credit (with a mean value of $US 2011). Indeed, they find that sales tax waivers have more than a ten-fold greater impact than tax credits. Access to HOV lanes for hybrid purchasers only has an impact in the state of Virginia. In particular, they also find “compelling” evidence that demand for the most fuel efficient hybrid vehicles rises with gasoline price increases. In particular, they estimate that a US$ 100 increase in annual fuel savings is associated with a 13 per cent increase in hybrid vehicle sales.

In a European context, van Vliet et al. (2010) simulate the adoption of alternative fuels in the Netherlands. They find that such adoption is limited to niche markets with shares of five per cent or less. In particular they find price to be an important factor in adoption, and that alternative fuels must be priced competitively with respect to current fuel sources. The authors feel that for the adoption of alternative fuels to be significant, intervention is essential and the policy must be transparent to consumers and policy stability is required. de Haan et al. (2009) examine the effects of government intervention on the choice of more energy efficient cars rather than the adoption of alternate technology. They employ a labelling scheme where very fuel efficient cars, labelled as Category A, receive a cash incentive for purchase; through to highly inefficient cars, labelled Category G, purchasers of which are required to pay additional fees. They allow switching through the selection of smaller cars or through smaller more efficient engines within the same vehicle class. They observe high policy efficacy in so much as benefits of the incentives outweigh loss in utility from decreased power and acceleration from smaller engines; and observe low market disturbance in that consumers can stay within a vehicle class and still receive the rebate by adjusting vehicle power rather than size.

Fullerton et al. (2005) evaluate vehicle emission incentive strategies in that Japan. Current policies in Japan include taxes on gasoline prices and the purchase prices of vehicles, including an acquisition tax equal to the value of five per cent of the acquisition price of the vehicle new or old. Via a two stage model of choice and usage, the authors examine four taxes designed to alter the price per kilometre, finding that whilst all taxes of this nature tended to encourage newer cars, a local emissions tax or a carbon tax had relatively slight changes compared to a distance based road user charge or an additional tax on gasoline (both of which also encouraged the no car options). They also find that purchase taxes based on the size of the engine size or on level of emissions only have minimal impacts on vehicle and distance choices. A tax on vehicle age has a similarly small impact. As a whole, the authors find that emission rates are most affected by taxes on gasoline.

Via simulation Hensher (2008) explores the impact of policies that are aimed at reductions in vehicle based emissions. Of the policies most related to vehicle choice and usage, a variable tax of 40 cents per kilogram of CO_2 is found to reduce emissions by five per cent in 2015 and a general improvement in vehicle fuel efficiency of 25 per cent achieves a 21 per cent reduction by 2015. Overall, the studies presented in this section suggest two incentive methods impact energy-efficient vehicle choice more than other policy initiatives: a higher taxation on vehicles with poor fuel efficiency (or conversely a tax rebate on more fuel efficient vehicles); and increasing the price of gasoline (implicitly an increase in the running cost of the vehicle).

4.3 Pricing negative externalities

Whilst significant gains in energy efficiency of new passenger cars are feasible at an acceptable cost from an engineering point of view (Greene and DeCicco 2000), historic trends of energy efficiency, weight and power of new passenger vehicles have shown that market forces favour increases in power and weight (de Haan et al. 2009, Turrentine and Kurani 2007, Zachariadis 2006). Additionally, despite the technological improvements that have occurred since the mid 1990's, the alternative fuel source that will ultimately emerge (biofuels, electric vehicles, hydrogen to name a few) as the dominating commercial fuel for much of the car market is as yet unclear. Consequently, until an acceptable and viable dominating technology is commercially practicable, the potential for specific fuel substitution remains an open question. Regardless of what technology solution ultimately triumphs, the affective nature of car ownership means it is unlikely that consumers will freely and readily change consumption practices without market intervention.

The previous section explored incentive structures designed to encourage the purchase of alternatively fuelled vehicles, however the government may also manipulate a range of price signals to only encourage behaviour with respect to new technology, but to also discourage the ownership of inefficient and environmentally damaging vehicles. One such method is to directly

tax fuel usage based on the fuel economy of the vehicle. For example, the United States has a "gas-guzzler tax" which is applied on a graduated scale based on a car's fuel economy rating. Britain has a more explicit annual tax linked directly to a vehicles measured carbon emissions, with higher emitting vehicles being charged a higher amount. Alternatively, economies such as the United States, Australia, Canada, Japan, and Thailand employ a direct taxation method levied on the price of petrol. Whilst increases in fuel prices has shown to be an effective instrument, increasing the cost of fuel via additional taxation may not be a palatable option for governments, particularly if consumers see it as an undefined revenue appropriation that is not explicit to its purpose. Thus, alternative strategies need to be explored.

One such policy that may be effective is pricing the externalities of vehicle use themselves. Pricing for road and vehicle usage is not a new economic concept, having existed in the form of fuel taxes, licence fees, car registration, parking taxes and tolls for many years. These taxes have been used to fund new infrastructure developments or to maintain existing infrastructure that is associated with vehicle use, one of the primary objectives of road and vehicle charging (Litman 2007). However, with respect to pricing specifically for road use many countries employ a largely laissez faire approach and these regimes are neither economically efficient nor equitable. That is to say, the prevalent road pricing policies currently do not accurately reflect the costs they impose when making a particular trip decision, and only if drivers pay full marginal costs will they limit their vehicle travel to trips in which benefits exceed costs.

Additionally, in congested conditions, the marginal cost of supplying one extra unit of road space increases above the average cost (Knight 1924). Moreover, road users should not only pay for the direct time and environmental costs that they impose on other road users and other people; they should also pay a charge corresponding to the increase in others' fuel costs and wear-and-tear costs (Johansson-Stenman 2006). Focusing firstly on congestion, economic efficiency would dictate that access to crowded roads should be rationed by prices that truly reflect the cost of the trip decision and in the light of economic arguments several cities have instituted congestion charging structures. As early as 1975, Singapore implemented the Area Licensing Scheme requiring drivers to purchase a special supplementary license which must be displayed on the vehicle when driven in designated Restricted Zones during peak hours. The drop in traffic entering the Restricted Zones was 31 per cent over the period from 1975 to 1988, despite one third growth of employment in the city, and by 77 per cent in vehicle population during the same time (Keong 2002). In 1998, the Area Licensing Scheme was replaced with Electronic Road Pricing, allowing for more frequent changes to the road pricing charges, allowing more optimised road use. Traffic volume into the restricted zone was reduced by approximately 10 to 15 per cent compared to the previous scheme over the period from 1998 to 2002, even with the road pricing charges being lower for this system (Keong 2002).

In 2003, London implemented a Congestion Charge Zone scheme with the objectives of reducing congestion as well as providing additional funding for other transport initiatives. Initially, the £8 entry charge covered an approximate 21 kilometre squared area of Central London. In 2007, the scheme was expanded to parts of West London. Since the scheme's implementation, it has been reported that traffic entering the original charging zone remains 21 per cent lower than pre-charge levels, with traffic entering the Western Extension fallen by 14 per cent. At the same time, there has been a six per cent increase in bus patronage during charging hours, and £137 million has been raised (TFL 2008).

Stockholm instituted a congestion charging system in 2006. The system consists of a cordon around the city centre, with a time-varying charge being levied for each crossing in any direction. The charged area covers around 30 square kilometres, roughly 50 per cent larger than the London charging area. The charge resulted in a bigger than forecast decrease in congestion (measured as "additional travel time"); near the cordon (where congestion was highest) 80-90 per cent of the queues are gone and further out from the cordon there are also large effects with around 50 per cent less queues (Eliasson and Hugosson 2006).

Congestion, however, is but one externality of vehicle use indeed many environmental problems stem from the use of transport infrastructure by passenger and freight vehicles, which are a source of local pollutants (Hensher and Button 2003) and represent a cost of vehicle ownership that is currently not reflected in purchase or usage decisions. In terms of vehicle emissions in Australia it is predicted that with no carbon price in place transport emissions will nearly quadruple by 2100 (Garnaut 2008). Accordingly, there has been a greater call for the better integration of policy with respect to a charging scheme to reduce CO_2 and local air pollution (Begg and Gray 2004) and using the similar economic argument for charging the externality of congestion, a pricing scheme can be developed that targets emission levels.

One of the first variable pricing schemes specifically linked to pollution outcomes was launched in Milan in 2008. The policy was driven by the desire to reduce the level of air pollutant emissions in the urban area. Under the scheme, to enter the central area of Milan by vehicle between the hours of 7:30am and 7:30pm, Monday to Friday, it is necessary to pay for and display an Ecopass ticket. The price of the ticket varies from €2 to €10 depending on the assessed environmental impact of the vehicle being driven. The stated objectives of the charging schemes are to reduce the number of vehicles entering the urban area by 30 per cent, reduce primary emissions from traffic and transportation by 25 per cent, and to promote more obsolete vehicles being excluded from the fleet (Croci 2007). Such environmental goals are not unrealistic, as the incidental impact of congestion charging in London meant that reduced traffic flows created positive environmental benefits. Compared to 2002 levels, as a result of the initial charging scheme implemented in 2003 NOX emissions in the charging zone were reduced by approximately 12.0 per cent, PM10 emissions were reduced by approximately 11.9 per cent, and there was a reduction in CO_2 emissions of 19.5 per cent (Beevers and Carslaw 2005). With respect to policies promote the choice of environmentally friendly vehicles, Beck et al. (2011) find that annual and variable emissions surcharges targeted very specifically to vehicle emission rates have a significant role in modifying vehicle purchasing decisions.

Hensher (2008) simulate a ten cent per kilometre user charge imposed on the main road network in Sydney between 7am and 6pm and find that CO2 from passenger cars is reduced 4.74 per cent by 2015. Technological advances have meant that variable distance based charging is becoming increasingly feasible. In 2008 the Dutch government announced a satellite-based road user charge (ITS International 2007) however in April 2010 this innovative program was deferred. A mileage fee pilot program in the city of Portland, Oregon, successfully tested area pricing and this conceptual system could be expanded to allow a virtually unlimited number of congestion and environmental pricing applications (ODT 2007). A key motivation for moving to a distance-based charging regime, notably the US, is the loss of a revenue base associated with less tax income from fuel due to more fuel-efficient vehicles. This is a critical issue shaping much of the current US policy planning discussion and is highly relevant in the context of the larger policy discussion of new charging schemes.

5. Conclusion

The automobile represents an important construct in the development of modern society. Perhaps no single consumer product has had as profound impact on society or continues to have a profound impact of those who own and operate them. Many of us are able to remember clearly our first car; either with either great fondness or equal frustration. A large number of people aspire to own a particular vehicle, or support a particular brand of vehicle with the fervour they support a sporting team. The automobile is an affective product where feelings, experiences and emotions can largely determine preferences. It is this passion which makes the vehicle an eminently suitable candidate for research across a range of disciplines. As economies and societies continue to change, developing countries increase their consumption of motor vehicles, and the technology associated with the production of automobiles continues to advance it is clear that the motor vehicle will remain a focal object, particularly for those in the

environmental sciences or planners charged with the development of cities and resultant infrastructure.

Given the indelible mark the vehicle has made on the lives of many, if policy makers wish to engender structural change in the purchasing and usage behaviour of motor vehicle owners, it seems that some form of market intervention is required rather than relying on a shift in consumer sentiment. Of particularly interest to those in environmental studies are the adverse effects that the motor vehicle has on the environment and the economy and how these might be abated. The market internalisation of a negative externality is such an intervention, one for which the economic arguments have been known for decades. However, while there is a large and growing literature on congestion charging (Whittles 2003) combined with several examples where the pricing of congestion has resulted in reductions in this externality (with the coincident improvements in environmental outcomes), there are very few studies that explore road pricing as a direct function of vehicle emissions. Within the literature that has examined methods to reduce vehicle emissions by changing vehicle choice, the focus is almost exclusively on the purchase of hypothetical, alternatively fuelled vehicles given a gamut of possible incentives to purchase those vehicles. However, the current number of alternative or hybrid vehicles in the market is limited to niche offerings, moreover there is research to suggest that hybrid purchase is largely a function of self-image (Sperling et al. 2004) further implying the existent of an idiosyncratic set of preferences among consumers who have a desire to purchase conspicuously green vehicles (Gallagher and Muehlegger 2010).

While much of the literature with respect to the automobile focuses on the negative aspects of the car, the studies discussed in this section reveal how the automobile has been a catalyst for many social relationships. Detailed scholarship on how the automobile is perceived, desired, obtained and used in everyday life by various individuals and social groups is limited (Koshar 2001), but given the emotional responses that automobiles elicit and how embedded they are in social networks, cars will not be easily given up just because they are dangerous to health, the environment or based on unsustainable energy consumption (Sheller 2004). Such policy challenges only serve to underline the ongoing enchantment of the motor vehicle.

References

Bao, J.Y.E. and J.C. Sweeney (2009). “Comparing Factor Analytical and Circumplex Models of Brand Personality in Brand Positioning.” *Psychology & Marketing* 26(10): 927-949.

Barthes, R. (1957). *Mythologies*, Editions du Seuil, Paris.

Beck M.J., J.M. Rose and D.A. Hensher (2011). “Behavioural Responses to Vehicle Emissions Charging.” *Transportation* 38(3): 445-463.

Beck, M.J., J.M. Rose and D.A. Hensher (2012). “The Accuracy of Proxy Responses in a Stated Choice Setting: A Re-examination and Some Controversial Conclusions.” *Transportation Research Part A* 46 (1): 226-239.

Beevers, S.D. and D.C. Carslaw (2005). "The Impact of Congestion Charging on Vehicle Emissions in London." *Atmospheric Environment* 39(1): 1-5.

Begg, D. and D. Gray (2004). “Transport Policy and Vehicle Emission Objectives in the UK: Is the marriage between transport and environment policy over?” *Environmental Science & Policy* 7(3): 155-163.

Ben-Akiva, M.E. and S.R Lerman (1974). “Some Estimation Results of a Simultaneous Model of Auto Ownership and Mode Choice to Work.” *Transportation* 3(4): 357-376.

Berry, S., J. Levinsohn and A. Pakes (1995). "Automobile Prices in Market Equilibrium." *Econometrica* 63(4): 841 – 890.

Berry, S., J. Levinsohn and A. Pakes (2004). "Differentiated Product Demand Systems from a Combination of Micro and Macro Data: The New Car Market." *Journal of Political Economy* 112(1): 68-105.

Bresnahan, T.F. and D.M.G. Raff (1991). "Intra-Industry Heterogeneity and the Great Depression: The American Motor Vehicles Industry, 1929-1935." *Journal of Economic History* 51(2): 317-331.

Brownstone, D., D.S. Bunch, T.F. Golob and W. Ren (1996). "A Transaction Choice Model for Forecasting Demand for Alternative-Fuel Vehicles." *Research in Transportation Economics* 4: 97-129.

Brownstone, D., D.S. Bunch and K.E. Train (2000). "Joint Mixed Logit Models of Stated and Revealed Preferences for Alternative-Fuel Vehicles." *Transportation Research Part B* 34: 315-338.

Brownstone, D. and K.E. Train (1999). "Forecasting New Product Penetration with Flexible Substitution Patterns." *Journal of Econometrics* 89: 109-129.

Bunch, D. S., M. Bradley, T.F. Golob, R. Kitamura and G. P. Occhiiuzzo (1993). "Demand for Clean-fuel Vehicles in California: A Discrete-Choice Stated Preference Pilot Project." *Transportation Research Part A* 27: 237-253

Choo, S. and P. Mokhtarian (2004). "What Type of Vehicle do People Drive? The Role of Attitude and Lifestyle in Influencing Vehicle Choice Type." *Transportation Research Part A* 38: 201-222.

Croci, E. (2007). "Milan: Pollution Charge - A Road Policy System." *5th European Conference on Sustainable Cities & Towns*, Sevilla, Spain.

Dagsvik, J. K., T. Wennemo, D.G. Wetterwald and R. Aaberge (2002). "Potential Demand for Alternative Fuel Vehicles." *Transportation Research Part B* 36(4): 361-384.

Davis, S.C. and L.F. Truett (2000). "An Analysis of the Impact of Sport Utility Vehicles in the United States." Office of Transportation Technologies, US Department of Energy,

http://cta.ornl.gov/cta/Publications/Reports/ORNL_TM_2000_147.pdf accessed 08.09.10

de Haan, P., M.G. Mueller and R.W. Scholz (2009). "How Much do Incentives Affect Car Purchase? Agent-Based Microsimulation of Consumer Choice of New Cars – Part II: Forecasting Effects of Feebates Based on Energy-Efficiency." *Energy Policy* 37: 1083-1094.

DeNavas-Walt, C., B.D. Proctor and J.C. Smith (2008). "Income, Poverty, and Health Insurance Coverage in the United States: 2008." *Current Population Reports*, US Census Bureau.

Derks, S. (2009). *The Value of a Dollar: Prices and Incomes in the United States, 1860-2009*. Grey House Publishing, Amenia NY.

Diamond, D. (2009). "The Impact of Government Incentives for Hybrid-Electric Vehicles: Evidence from the US States." *Energy Policy* 37: 972-983.

EEA (2008). "Annual European Community Greenhouse Gas Inventory 1990-2006 and Inventory Report." *European Environment Agency*, Copenhagen.

Eliasson, J. and M.B. Hugosson (2006). "The Stockholm Congestion Charging System – An Overview of the Effects After Six Months." *European Transport Conference 2006.* Strasbourg, France.

Fang, A.H. (2008). "A Discrete-Continuous Model of Households' Vehicle Choice and Usage, With an Application to the Effects of Residential Density." *Transportation Research Part B* 42: 736-758.

Fullerton, D., L. Gan and M. Hattori (2005). "A Model to Evaluate Vehicle Emission Incentive Policies in Japan." *Working Paper*: http://works.bepress.com/don_fullerton/10.

Gallagher, M.S. and E. Muehlegger (2010). "Giving Green to get Green? Incentives and Consumer Adoption of Hybrid Vehicle Technology." *Journal of Environmental Economics and Management* In-print: accessed online 5.11.10.

Garnaut, R. (2008). "Transforming Transport." *The Garnaut Climate Change Review*, www.garnautreview.org.au accessed 10.11.08.

Gartman, D. (1994). *Auto Opium: A Social History of American Automobile Design*. Routledge, London pp. 203 citing the Wall Street Journal.

Golob, T.F., J. Torous, M. Bradley, D. Brownstone, S.C. Soheila, D.S. Bunch (1997). "Commercial Fleet Demand for Alternative-Fuel Vehicles in California." *Transportation Research Part A* 31: 219-233.

Golob, T.F. and J. Gould(1998). "Projecting Use of Electric Vehicles from Household Vehicle Trials." *Transportation Research Part B* 32: 441-454.

Greene, D.L. and J. DeCicco (2000). "Engineering-Economic Analysis of Automotive Fuel Economy Potential in the United States." *Annual Review of Energy and the Environment* 25: 477-536.

Hensher, D.A. (2008). "Climate Change, Enhanced Greenhouse Gas Emissions and Passenger Transport – What Can We Do to Make a Difference?" *Transportation Research Part D: Transport and Environment* 13(2): 95-111.

Hensher, D.A., M.J. Beck and J.M. Rose (2011). "Accounting for Preference and Scale Heterogeneity in Establishing Whether it Matters Who is Interviewed to Reveal Household Automobile Purchase Preferences." *Environmental and Resource Economics* 49(1): 1-22.

Hensher, D.A. and K.J. Button (2003). "Transport and the Environment." *Handbook of Transport and the Environment*. D. A. Hensher and K. J. Button, Emerald Group Publishing.

Hensher, D.A. and W.H. Greene (2001). "Choosing Between Conventional, Electric and LPG/CNG Vehicles in Single-Vehicle Households." in D.A. Hensher (ed) *The Leading Edge of Travel Behaviour Research*, Pergamon Press, Oxford, 725-750.

Hensher, D.A., J.M. Rose, I. Black (2008). "Interactive Agency Choice in Automobile Purchase Decisions: The Role of Negotiation in Determining Equilibrium Choice Outcomes." *Journal of Transport Economics and Policy* 42(2): 269-296.

Hess, S., M. Fowler, T. Adler, A. Bahreinian (2009). "A Joint Model for Vehicle Type and Fuel Type Choice." *European Transport Conference*, Leeuwenhorst, The Netherlands.

ITS International (2007). "Dutch decide on national road user charging scheme." http://www.itsinternational.com/news accessed 05.12.07.

Johansson-Stenman, O. (2006). "Optimal Environmental Road Pricing." *Economics Letters* 90(2): 225-229.

Kavalec, C. (1996). "CALCARS: The California Conventional and Alternative Fuel Response Simulator – A Vehicle Demand/Choice Model for California." *Staff Report Number P500-96-003*, Sacramento, California Energy Commission.

Keong, C.K. (2002). "Road Pricing: Singapore's Experience." *Third seminar of the IMPRINT-EUROPE Thematic Network: Implementing Reform on Transport Pricing: Constraints and solutions: Learning from Best Practice*, Brussells.

Knight, F. (1924). "Some Fallacies in the Interpretation of Social Cost." *Quarterly Journal of Economics* 38(4): 582-606.

Koppel, S., J. Charlton, B. Fildes and M. Fitzharris (2008). "How Important is Vehicle Safety in the New Vehicle Purchase Process?" *Accident Analysis & Prevention* 40(3): 994-1004.

Koshar, R. (2001). "On the History of the Automobile in Everyday Life." *Contemporary European History* 10: 143-154

Li, S., C. Timmins and R.H. von Haefen (2009). "How Do Gasoline Prices Affect Fleet Fuel Economy" *Economic Policy* 1(2): 113-137

Litman, T. (2007). "Road Pricing: Congestion Pricing, Value Pricing, Toll Roads and HOT Lanes." *Victoria Transport Policy Institute*: http://www.vtpi.org/tdm/tdm35.htm accessed 26.11.10.

Martin, E.W. (2009) "New Vehicle Choice, Fuel Economy and Vehicle Incentives: An Analysis of Hybrid Tax Credits and the Gasoline Tax." *UCTC Dissertation No. 164*, University of California Transportation Center, University of California, Berkeley.

Miles, S. (1998). *Consumerism – As a Way of Life*. SAGE Publications, London.

MuConsult (2005). "A New Model for Car Ownership in the Nederlands." *AVV Transport Research Centre*, Nederlands.

NADA: National Automobile Dealers Association (2009). "Economic Impact of America's

New-car and New-truck Dealers: A Dealership and Industry Review" via www.nada.org/nadadata accessed 23.08.10.

ODT (2007). "Oregon's Mileage Fee Concept and Road User Fee Pilot Program." *Oregon Department of Transport*. www.oregon.gov/ODOT/HWY/RUFPP/docs/RUFPP_finalreport.pdf accessed 21.11.08.

Potoglou, D. (2008). "Vehicle-type Choice and Neighbourhood Characteristics: An Empirical Study of Hamilton, Canada." *Transportation Research Part D* 13: 177-186.

Potoglou, D. and P.S. Kanaroglou (2007). "Household Demand and Willingness to Pay for Clean Vehicles." *Transportation Research Part D* 12(4): 264-274.

Sheller, M. (2004). "Automotive Emotions." *Theory, Culture and Society* 21(4/5): 221-242.

Small, K. A. and K. Van Dender (2007). "Long Run Trends in Transport Demand, Fuel Price Elasticities and Implications of the Oil Outlook for Transport Policy." Joint Transport Research Centre; Discussion Paper 2007-16.

Sperling, D, D.S. Bunch, A. Burke (2004). "Analysis of Auto Industry and Consumer Response to Regulations and Technological Change, and Customisation of Consumer Response Models in Support of AB 1493 Rulemaking." *Institute of Transportation Studies*, University of California Davis.

Steg, L. (2005). "Car Use: Lust and Must. Instrumental, Symbolic and Affective Motives for Car Use." *Transportation Research Part A* 39: 147-162.

Train, K.E. (1986). *Qualitative Choice Analysis: Econometrics and an Application to Automobile Demand*. Cambridge, MIT Press.

Train, K.E. and C. Winston (2007). "Vehicle Choice Behavior and the Declining Market Share of U.S. Automakers." *International Economic Review* 48(4): 1469-1496.

TFL (2008). "Benefits of Congestion Charging." *Transport for London* http://www.tfl.gov.uk/roadusers/congestioncharging/6723.aspx accessed 28.10.08.

Turrentine, T.S. and K.S. Kurani (2007). "Car Buyers and Fuel Economy?" *Energy Policy* 35: 1213-1223.

Van Vliet, O., B. de Vries, A. Faaij, W. Turkenburg and W. Jager (2010). "Multi-Agent Simulation of Adoption of Alternative Fuels." *Transportation Research Part D* 15(6): 326-342.

Williamson, S.H. (2011) "Seven Ways to Compute the Relative Value of a U.S. Dollar Amount, 1774 to Present." Measuring Worth, http://www.measuringworth.com/uscompare accessed 20.04.11.

Whittles, M.J. (2003). *Urban Road Pricing: Public and Political Acceptability,* Aldershot, Ashgate Publishing.

Zachariadis, T. (2006). "One the Baseline Evolution of Automobile Fuel Economy in Europe." *Energy Policy* 34: 1773-1785.