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Michael Perkins
Clemson University, msperkins17@gmail.com

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HEDONIC ANALYSIS OF THE WILLINGNESS TO PAY FOR FUEL EFFICIENCY IN THE AUSTRALIAN AUTOMOBILE MARKET

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
Economics

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by
Michael Shane Perkins
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Accepted by:
Dr. Scott R. Templeton, Committee Chair
Dr. Michael T. Maloney
Dr. Raymond D. Sauer
Dr. Molly Espey

ABSTRACT

The implicit prices of automobile attributes are estimated with a hedonic model of new automobiles sold in the 2005 Australian market. The estimated marginal value of decreased fuel consumption is found to be positively valued by drivers and car manufacturers. A comparison of explicit fuel savings estimated with Australian automobile market statistics to the implicit fuel savings estimated with the hedonic regression indicates that new automobile buyers accurately value the fuel cost savings associated with reductions in fuel consumption.

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I would like to thank Sam Murray for his significant contribution to the creation of the dataset and Natasha Brown for her assistance in making sure data were properly entered. At last I would like to express appreciation for the employees at Red Book Australia for answering a number of my questions.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

The potential scale of global climate change has induced and, to an extent, prioritized the organization of various national and multinational regulatory efforts that aim to reduce harmful emissions and promote energy efficiency. The rationale for government intervention goes beyond environmental concerns. Increases in oil consumption around the globe, largely as a result of drastic demand increases in Asia, have hastened the exhaustion of oil reserves. From 2000 to 2007, the average annual world consumption of oil grew by 11.6% (British Petroleum), and, notwithstanding the impact of the current economic recession, consumption is projected to continue increasing while developing nations continue to experience rapid economic growth. Political instability and cartel induced supply cuts in the Middle East tremendously influence the international price of oil (Portney et al. 2003). Governments and international governing bodies can intervene in various markets to make consumers of gasoline account for external costs associated with emissions of greenhouse gases. Methods of market intervention include standards, taxes, subsidies, other financial incentives, voluntary agreements, awareness campaigns, tradable permits, and legally binding commitments.

However, government intervention can often result in perverse incentives. The U. S. government's regulation of the automobile industry in the 1970's with a minimum average fuel economy for each manufacturers' model year fleet, known as Corporate

Average Fuel Economy (CAFE), has been criticized for the perverse incentives it creates and for its relative ineffectiveness. The policy was implemented because the government did not think that automobile producers had an effective market signal to produce fuel efficient automobiles. This perception was accurate because government policies before CAFE implementation in 1978 had artificially suppressed fuel prices. Thus prices did not reflect the rising scarcity that ultimately resulted in the rationing of oil in the mid- and late-1970s. Minimum fuel economy requirements have also been harmful to domestic business during periods of reduced fuel costs as consumers shifted their desires away from the smaller cars that domestic producer fleets are largely composed of to meet CAFE standards. The ultimate result is that consumers either pay higher vehicle prices or incur costs as a consequence of diminished performance (Crandall 1985). Opponents of increased fuel economy standards commonly cite the tradeoff between increased fuel efficiency and automobile safety. In order to comply with the increased standards and to avoid the costs of noncompliance, automobile manufacturers will produce lighter cars, at the expense of automobile safety (Crandall 1985). Others cite issues of freedom of choice, and the potential for increased automobile congestion due to the inducement for motorists to increase miles driven with improvements in fuel economy. However, there is evidence that the standards have contributed to increased fuel economy of the nation's light duty vehicle fleet, reduced dependence on foreign oil, and reduced emissions of carbon dioxide (BEES). Incentives play an important role in the automobile industry and the extent to which consumers and producers can efficiently respond to market signals, such as rising and falling fuel prices, without government influence is the source of much debate.

Worldwide, there were approximately 806 million cars and light trucks on the road in 2007, together burning over 260 billion gallons of fuel every year (Plunkett Research). Motor vehicles are a major contributor to air pollution, global warming, and the depletion of fossil fuels. In 2005, the transport sector was the third largest anthropogenic contributor of carbon dioxide and accounted for 23% of the total world market share. Within the transport sector, road transportation contributed to 73% of the carbon-dioxide emissions, thus contributed to approximately 16.8% of the total anthropogenic carbon dioxide emissions released in 2005 (ITF). In light of the considerable contribution of road transportation to anthropogenic carbon-dioxide emissions, the automobile market has experienced regulations in the form of fuel taxes, tailpipe emissions regulations, fleet average fuel economy standards, gas guzzler vehicle taxes, and subsidies for fuel efficient technologies.

The Australian Market

With over 14 million registered vehicles on the road, the transport sector is the third largest, as well as the fastest growing, source of carbon emissions in Australia. Unlike the US automobile market, the Australian market has been subjected to less stringent government intervention. Specifically, the Australian market is not governed by mandated fuel economy standards. However, other policies aim to reduce emissions and improve fuel efficiency. Labeling regulations were set into motion in October 2008.

They require that all new cars on the producer's lot display a sticker that states the fuel consumption and carbon-dioxide emissions of the automobile. The Green Car Innovation Fund is another government initiated program that supports innovation in the passenger vehicle sector by subsidizing technological advancement. A voluntary national average fuel consumption target of 6.8 liters per100 kilometers for petrol passenger cars by 2010 was negotiated by the government and the Federal Chamber of Automotive Industries (Australian Transport Council). Mandated fuel economy standards are being strongly considered as a necessary regulatory avenue for lowering travel costs and carbon emissions of Australian motorists. Several of the standards being considered include carbon dioxide emission targets for new light vehicles (mandatory or voluntary), direct financial incentives for low emission vehicles, fleet purchasing frameworks that incorporate carbon dioxide reduction objectives, and differential registration and stamp duty charges for new light vehicles based on carbon dioxide emissions (Australian Transport Council).

CHAPTER TWO

PREVIOUS LITERATURE

The automobile industry has been exhaustively investigated by economists and other market researchers for decades. Economists have empirically analyzed and estimated the supply and demand interactions of the automobile market using various methods. Demand and supply analysis of differentiated product markets, like the automobile market, has often been conducted through hedonic price analysis. According to the Lancaster model (1966) and to the Griliches approach (1961), the price of cars reflects the valuation of the characteristics embodied in the different models, through the optimization of consumer and producer choices in the market (as in Couton, Gardes, and Thepaut 1966). Pioneer hedonic analysis of automobiles involved the estimation of quality-adjusted prices (Court, 1939; Triplett, 1969, 1986; Cowling and Cubbin, 1971; Griliches, 1971; Ohta and Griliches, 1986; as in Espey and Nair 2005). Later research focused on the willingness-to-pay for human life and the valuation of safety characteristics (Atkinson and Halvorsen, 1990; Dreyfus and Viscusi, 1995; Dunham, 1997; as in Espey and Nair 2005), the extent of producer market power in different locations (Mertens and Ginsburgh, 1985; Thompson, 1987 as in Espey and Nair 2005), and the link between automobile quality and warranties (Douglas et al., 1993 as in Espey and Nair 2005).

In previous estimates of the marginal willingness-to-pay for fuel economy, the fuel economy attribute has either been excluded or reported as insignificant due primarily to its high correlation with other attributes included in the model. Many hedonic studies have noted that multicollinearity among attributes has resulted in the inaccurate and implausible estimation of attribute prices (Atkinson and Halvorsen 1984). These studies often reveal theoretically inconsistent signs on attribute coefficients, particularly when estimating the implicit marginal price of automobile fuel efficiency. Arguea and Hsiao (1993) and Thompson (1987) both included fuel economy, measured as miles per gallon (mpg), in their hedonic analyses of automobile markets. Both studies found fuel economy to be insignificant and inconsistent. According to Atkinson and Halvorsen (1984), "Automobile fuel efficiency is not desired for its own sake but influences consumers' decisions because it affects the cost of operating an automobile." Therefore fuel economy is fundamentally important to automobile price analysis because it is thought to be valued by consumers for the fuel savings it provides. Accordingly, automobile price is more precisely modeled as a function of fuel consumption (gallons per mile) because the value of fuel savings from a decrease in gallons per mile is directly related to the fuel price per gallon multiplied by miles driven (Espey and Nair 2005). As the inverse of fuel economy, fuel consumption decreases with increases in fuel economy. In contrast to the studies that entered fuel economy directly into the hedonic model as miles per gallon, Atkinson and Halvorsen (1984), Dreyfus and Viscusi (1995), and Berry et al. (1995) aptly used fuel consumption, the inverse of fuel economy in their hedonic analysis. Espey and Nair (2005) similarly employed the inverse. However, they did not explicitly include fuel price and miles driven in their model because "miles driven may either influence a consumer's choice of fuel economy or be influenced by the fuel economy of the vehicle purchased. In either case, the implicit price of fuel economy would be expected to reflect the consumer's fuel cost savings, which would be a function of the consumer's expectation of future fuel prices and vehicle miles to be driven." Similar to Espey and Nair (2005), the hedonic model employed in this analysis considers fuel consumption, in particular liters per one-hundred kilometers, and it does not assume fuel prices or distance driven explicitly in the model.

Ohta and Griliches (1986) (as in Espey and Nair 2005) used the semi-logarithmic form of the hedonic model to measure the effect of gasoline price increases on consumer preferences; Couton, Gardes and Thepaut (1995) also used the semi-logarithmic form to estimate hedonic prices for environmental and safety characteristics of automobiles and to look for evidence of the Akerlof effect in the French automobile market. Hedonic analysis in this study will take a linear form, similar to that employed by Espey and Nair (2005), instead of the semi-logarithmic form. The direct relationship between automobile price and fuel cost savings required by the semi-logarithmic model implies diminishing marginal costs in the supply of particular attributes (Thompson 1987). This constraint is undesirable when estimating the marginal price of fuel cost savings because it implies that the marginal price decreases as vehicle prices increase, thus the semi-logarathmic form is not used in this paper.

CHAPTER THREE

METHODOLOGY

Model

Consumer willingness to pay for reduced fuel consumption, or fuel cost savings, will be evaluated in accord with the procedures developed by Rosen (1974). Automobiles represent differentiated products valued by consumers for the utility derived from the various characteristics and attributes they provide. A consumer purchases an automobile for the transportation services it provides. Utility-bearing attributes from the travel services include safety, comfort, size, power, performance, and fuel consumption. Consumers often face tradeoffs among attributes, particularly with fuel consumption. Reductions in fuel consumption, or increases in fuel efficiency, are sometimes achieved at the expense of safety, size, power, and speed (Australian Transport Council). Automobiles represent differentiated bundles of attributes that, when in competitive equilibrium, are priced by the interaction of producers and consumers for various bundles or packages of attributes. (Espey and Nair, 2005) The same model used by Espey and Nair (2005) will be used in this analysis, where the price of an automobile is represented by:

$$P_{Auto} = P(\mathrm{A}_1, \mathrm{A}_2, \mathrm{A}_3, \ldots, \mathrm{A}_n) \tag{1}$$

Each A_i is an attribute or characteristic of the automobile. The implicit marginal price of any one A_i (attribute) can be calculated by taking the partial derivative of the equilibrium hedonic price function with respect to the attribute:

$$p(A_k) = \partial P_{Auto} / \partial A_k \qquad (2)$$

This value has implications for both producers and consumers. The interaction of producers and consumers in the marketplace determines the optimal product price (Espey and Nair 2005). The implicit marginal price of an attribute reveals the consumer's marginal willingness to pay for an additional unit of that attribute and the producer's marginal cost of providing an additional unit of that attribute in that vehicle in market equilibrium, where marginal revenue equals marginal cost.

Data and Variables

Vehicle prices and the majority of the vehicle attribute observations for the hedonic model were obtained from the Red Book Australia website, which reports extensive attribute data on historical new and used automobiles. Accident data from the Monash University Accident Research Center was used to create two variables that characterize automobile safety using.

The hedonic price model was estimated with 944 observations of new passenger vehicles. All of the passenger vehicles included in this dataset were selected from particular vehicle segments defined by the December 2006 VFACTS National Report on new vehicle sales. Passenger cars came from the small, medium, large, and upper large (<AUD $100K) segments. Observations about sport utility vehicles came from the SUV compact, SUV medium, SUV large, and SUV luxury segments. A further restriction imposed on the dataset was for vehicle observations not classified into distinct market

groups by the Monash report. These observations were not included in the hedonic regression because the number of observations to reliably estimate the relative safety of vehicles was insufficient.

The dataset accounts for an array of desirable vehicle attributes such as safety, attractiveness, comfort, size, performance, power, reliability, and fuel consumption. Contrary to the work of Espey and Nair (2005), SUVs and passenger vehicles are both included in this analysis under the assumption that buyers of new automobiles choose among both. Further, SUVs and passenger vehicles are not subject to different regulations in Australia as they are in the U.S. (Espey and Nair 2005). Table 1 below displays the summary statistics for the variables included in the hedonic model.

Table 1: Summary Statistics

Variable	***Mean***	***Std. Dev.***	***Min***	***Max***
RRPRICE (AUD $)	38971.97	17814.52	12990.00	140900.00
PINJURY (%)	16.18	3.72	8.23	27.11
PSEVEREINJ (%)	15.75	6.00	3.03	31.82
ALLOY	0.71	0.45	0.00	1.00
LEATHSEAT	0.24	0.42	0.00	1.00
FUELCAP (L)	66.30	25.98	40.00	180.00
PEAKPOW (kW)	121.83	42.29	55.00	260.00
CURB (kg)	1452.94	355.02	850.00	2645.00
WHEELBASE (mm)	2629.82	147.71	2200.00	2980.00
RESALEKM (%/100km)	68.48	15.26	34.75	127.84
FCONS (L/100km)	9.52	2.36	4.90	17.70

RRPRICE (AUD $) is the recommended retail price of each automobile when new. Recommended retail prices from the manufacturer do not include dealer-on-road costs, such as warranty, registration, and delivery costs. The actual market transaction price for each new vehicle is not available. The recommended retail price is very similar, if not identical, to the list price used by Espey and Nair (2005). The RRPRICE of passenger vehicles ranges from a minimum of $12,990 for the Holden Barina to $140,900 for the Mercedes-Benz ML55. The mean RRPRICE for the hedonic model observations is $38,971. The Holden Barina is in the light car segment (VFACTS) and market group (Monash), and in 2005 9,675 new Barinas' were sold in Australia. The Mercedes-Benz ML55 is in the luxury SUV segment and under the 4WD large market group, and only 1,240 new ML55s' were sold.

FCONS (liters per 100 kilometers) represents the combined urban (city) and extra urban (highway) fuel consumption of each of the automobiles. Fuel consumption estimates are calculated according to defined procedures specified by the Australian Design Rules (ADRs). ADR81/01 specifies that the testing procedures must comply with the United Nations Economic Commission for Europe Regulation 101. Calculation of the combined fuel consumption depends on unequal weights for urban and extra urban fuel consumption. The estimates reported for fuel consumption do not always depict reality. The road and driving conditions, the condition of the vehicle, and differences in driving styles can lead to varying results (Green Vehicle Guide). The average fuel consumption for new 2005 passenger vehicles, both cars and SUVs, is approximately 9.52L/100km. The Nissan Patrol Wagon, found in the large SUV segment and large

4WD market group has the highest fuel consumption with an estimated 17.7L/100km and the Peugeot 307, representing the small car segment and market group, has the lowest consumption estimated at a mere 4.9L/100km.

PEAKPOW (kW) is the maximum engine power capable of being generated. It is measured in kilowatts in this model, although Berry, Levinsohn and Pakes (1995) measured engine power by dividing horsepower by curb weight and Espey and Nair (2005) used acceleration to indicate power. PEAKPOW is assessed at so called redline rpm. CURB (kg) is the total weight of a vehicle with standard equipment, all necessary operating consumables such as motor oil and coolant, a full tank of fuel, and no occupants or cargo. As Espey and Nair (2005) point out, curb weight, length, width and wheelbase are all indicators of size. However, CURB is probably the best indicator since the length and width are only one-dimensional and wheelbase can vary across similar size vehicles depending on the design. They also point out that CURB has the highest average correlation with the other three size indicators, making it a plausible size indicator. Due to similar correlation results[1] CURB is used to indicate vehicle size in this paper as well. WHEELBASE (mm) represents the distance between the centers of the front and rear two wheels; the distance is from the front bumper to the rear bumper. The

1 Correlation of Vehicle Size Indicators:

	curb	***wheelbase***	***length***
wheelbase	0.78		
length	0.79	0.83	
width	0.68	0.65	0.57

longer the wheelbase, the harder the vehicle is to turn because of the increased radius of the turning circle. FUELCAP (liters) is the volume of the vehicle's fuel tank.

Two dummy variables are included in the analysis. ALLOY indicates aluminum alloy wheels instead of steel. Alloy wheels are more intricately designed and flashy, more expensive to produce, and usually weigh less than standard steel wheels. As a result, they are associated with both improved aesthetics and driving performance. LEATHSEAT indicates leather seats. Leather seats are associated with other luxurious amenities and therefore increased vehicle comfort.

RESALEKM equals the ratio of the mean private sale price of an automobile after approximately one year of use to the recommended retail price of the automobile when new per mean 100,000 kilometers driven:

$$RESALEKM = \frac{\left\{\frac{Mean\ Private\ Sale\ Price}{RRPRICE}\right\}\times 100}{\left\{\frac{Mean\ km\ Driven}{100{,}000}\right\}} \quad (4)$$

The private sale price is an evaluation of the price range that used car buyers can expect to pay (or receive) for a vehicle bought (sold) in the private market (Red Book AU). The mean private price is the average of the private sale price range, the low and high value, listed by Red Book Australia. The values are based on a range of expected kilometers driven, and the average of this range determines the mean kilometers driven. The private sale price observations are the assessments listed for February 2009. Private market sales are not conducted through a dealer, thus there is no provision of warranty coverage or marketable standards.

PINJURY is the probability of injury given an accident. PSEVEREINJ is the probability of being severely injured given an injury. The safety variables were calculated using the following equations:

$$PINJURY = \frac{\#\,Injured}{\#\,Involved\ in\ Accident} \times 100 \quad (5)$$

$$PSEVEREINJ = \frac{\#\,Severely\ Injured}{\#\,Injured} \times 100 \quad (6)$$

Both of the safety probabilities were calculated using the Monash report's estimates of the relative safety of vehicles in preventing injury and severe injury to actual drivers in crashes. The reports estimates were based upon crash data from Queensland, Western Australia, and New Zealand during 1991 – 2005, from Victoria and New South Whales during 1987 – 2005, and in South Australia during 1991 – 2005.

CHAPTER FOUR

EMPIRICAL RESULTS

A linear regression model is estimated using ordinary least squares. All of the variables are found to be statistically significant at the 95% confidence interval and all of the coefficients are of the expected sign. According to the R-squared value, approximately 81% of the variation in the recommended retail price of new automobiles can be explained by the variables specified in this hedonic model. The elasticity estimates reported for each of the variables are also all significant at the 95% confidence interval and of the expected sign. Table 2 reports the empirical results of the hedonic regression. The estimated coefficients are reported in the second column, the third column reports the standard error, and the last column reports the elasticity (η) at the mean of the ratio for each of the variables.

Table 2: Empirical Results

EXPLANATORY VARIABLE	***Coefficient***	***Std. Err.***	***η***
PINJURY (%)	-505.50	107.82	
PSEVEREINJ (%)	-249.66	43.68	
ALLOY	3160.83	649.23	
LEATHSEAT	13397.69	676.66	
FUELCAP (L)	54.71	19.86	0.10
PEAKPOW (kW)	168.12	11.15	0.57
CURB (kg)	34.85	1.93	1.45
WHEELBASE (mm)	-28.57	3.14	-2.30
RESALEKM (%/100Km)	79.64	20.29	0.17
FCONS (L/100km)	-1754.45	226.45	-0.48
CONSTANT	57317.21	8484.97	
R^2	0.81		

The coefficients on FCONS, PINJURY, PSEVEREINJ, and WHEELBASE are all negatively related to RRPRICE. All else equal, a one liter per 100 kilometer reduction in fuel consumption (FCONS) is estimated to raise the price of a new 2005 passenger vehicle by $1754.45 in the Australian market. All else equal, a one percentage point increase in PINJURY reduces the price of an automobile by about $505.50. An identical increase in PSEVEREINJ reduces the price by approximately $249.66, *ceteris paribus*. Lastly, a one hundred millimeter increase in wheelbase is estimated to reduce the price of an automobile by about $2857, all else equal.

ALLOY, LEATHSEAT, FUELCAP, PEAKPOW, KERB, and RESALEKM all have a positive relationship with price. The coefficient on ALLOY reveals that new automobile prices in the 2005 Australian market are, on average, $3160.83 higher for passenger vehicles with alloy wheels. A one kilowatt increase in PEAKPOW is estimated to raise the price of an automobile by $168.12, *ceteris paribus*. Vehicles with leather seats cost, on average, $13397.69 more than vehicles without leather seats. A one liter increase in FUELCAP increases the price of a vehicle by approximately $54.71, *ceteris paribus*. A one percentage point increase in RESALEKM increases the price by about $79.64. A one kilogram increase in the weight (CURB) of an automobile leads to an increase of $34.85 in the automobile's price, *ceteris paribus*.

Taking the absolute value of the elasticity estimates calculated for the hedonic price model's independent variables reveals that only two of the variables, WHEELBASE (η = -2.30) and CURB (η = 1.45), have an elasticity greater than one. Elasticity values greater than one indicate greater responsiveness to changes in price.

FUELCAP (η = 0.10), PSEVEREINJ (η = -0.12), PINJURY (η = -0.27), and RESALEKM (η = .17) have inelastic values due to the proximity of their measures to zero (since η = 0 is perfectly inelastic). Values that are relatively inelastic indicate that changes in price will have little impact on the quantity of the good demanded or supplied PEAKPOW (η = 0.57) and FCONS (η = -0.48) also have inelastic estimates.

CHAPTER FIVE

DISCUSSION

Hedonic Model Analysis

FUELCAP, PEAKPOW, CURB, RESALEKM, LEATHSEAT, and ALLOY are all expected to contribute positively to the recommended retail price of new passenger vehicles. PINJURY, PSEVEREINJ, WHEELBASE, and FCONS are all expected to contribute negatively to price.

The coefficient on fuel consumption (FCONS) is expected to be negative because decreases in fuel consumption reduce fuel costs, resulting in a higher willingness to pay for the automobile. Higher fuel costs associated with higher levels of fuel consumption are expected to lower the willingness to pay for a vehicle, *ceteris paribus*. The estimated coefficient on fuel consumption measured by the hedonic regression is the implicit price of the fuel cost savings attribute since consumers are thought to value fuel economy or consumption for the fuel cost savings it provides. Fuel consumption reveals more transparent information to consumers in the market for a new automobile than fuel economy does. Fuel consumption directly affects the cost of driving the car and the amount of greenhouse gas emissions. Therefore differences observed in fuel consumption provide a direct measure of fuel savings and changes in carbon emissions, while differences in miles per gallon do not. Consideration of the benefits of improved fuel economy can be deceptive because equivalent increases in fuel economy are not equal in fuel savings. In essence, small improvements in miles per gallon for relatively inefficient automobiles are more valuable, in terms of fuel savings, than similar improvements in fuel economy for relatively efficient automobiles. Thus direct comparisons of miles per gallon can be quite misleading. By considering liters per 100 km, or liters of fuel used over some given distance, direct comparisons are no longer misleading. Fuel economy is not entirely useless as it does reveal the range of the automobile's gas tank; which lets the driver know how long they can drive until they need to refill their tank. Accordingly, fuel economy is useful when operating an automobile and fuel consumption is useful when purchasing an automobile. The fuel cost of operating an automobile is fuel price per liter multiplied by kilometers driven multiplied by fuel consumption:

$$\frac{\$}{L} \times 100\ km\ driven \times \frac{L}{100\ km} \tag{7}$$

WHEELBASE has a negative relationship with recommended retail price since, all else equal, increases in the length of the wheelbase increase a vehicle's turning radius. Both safety variables measure the probability of being injured, thus an increase in either of their probabilities will decrease consumers' desire for the less safe vehicle. The probability of severe injury given injury depends on the probability of injury given accident. Interpretation of the coefficients on PINJURY and PSEVEREINJ is not as straightforward as the other coefficient estimates. An increase in the probability of injury given an accident might lead to an increase in the probability of severe injury given an injury.

The magnitude of the dummy variables on automobile price may seem high. One must fully consider the actual indications of these variables. Few people would pay $13,397.69 for leather seats in their vehicle. However, as an indicator for luxury vehicles and comfort, the dummy variable captures various unmeasured luxurious attributes that are often bundled with leather seats. The coefficient on ALLOY, although smaller in magnitude, similarly captures unmeasured attributes that are often bundled with flashy wheels like chrome trimming or a spoiler.

A positive relationship is expected for RESALEKM because the higher is private used vehicle price's share of the new vehicle price the more the vehicle maintains its value and the less it depreciates. Slower depreciation of a vehicle can be thought of as an indicator of reliability, an attribute that one expects consumers to positively value. The reliability of a particular automobile, at the time of purchase, cannot be completely determined by the consumer. The private market value of a used automobile to the purchaser of a new vehicle at the time the vehicle is purchased is based on expectations of the reliability and durability of the vehicle and of the future market conditions for that particular vehicle. Roach (2008) measures the marginal effects of quality changes on the market-clearing price in wholesale automobile auctions and finds evidence that the market value for certain quality changes might actually be a market signal of adverse selection. Roach determines that resale values are based almost completely on mileage.

The estimate of the effect of price deprecation per average distance driven is provisional for two related reasons. First, the recommended retail price, which enters into the denominator of RESALEKM, is endogenous. Second, the average distance that a car is driven depends on fuel consumption. Hence, RESALEKM is also correlated with FCONS. A procedure to estimate the model and properly account for the partial endogeneity of RESALEKM and its correlation with FCONS is needed in future research.

The positive coefficient on CURB was expected because increases in vehicle size imply increases in space and safety. Vehicles that are more spacious and safer typically are more costly to manufacture because more raw materials are used. The positive relationship between PEAKPOW and price implies that consumers' are willing to pay for increased automobile speed and power, for a given amount of fuel consumption.

Price elasticity coefficients are informative in hedonic price analysis because they indicate the change in price that would result from a one percent change in a particular variable. The price elasticities are calculated with the variable coefficients obtained from the hedonic regression where the coefficients represent the marginal prices of various attributes in the model. The marginal price of a particular attribute in the hedonic model is obtained by taking the partial derivative of the equilibrium hedonic price model with respect to the attribute or characteristic of interest. Multiplying the estimated coefficient by the mean of the ratio of the variables, the attribute divided by price for all of the observations included in the model. The price elasticity for fuel consumption (FCONS) is this:

$$\eta = \frac{\partial RRPRICE}{\partial FCONS} \times \left\{\frac{\overline{FCONS}}{RRPRICE}\right\} \tag{8}$$

The price elasticity of FCONS is -0.48. The negative sign indicates that increases in fuel consumption and, thus, operating costs lead to reductions in the marginal willingness to pay for an automobile, all else equal. Based on the elasticity value the willingness-to-pay for reduced fuel consumption is relatively price inelastic. A 10% reduction in fuel consumption would lead to a 4.8% increase in vehicle price. A reduction in fuel consumption of this magnitude from the mean (from model sample) fuel consumption of passenger vehicles of 9.52L/100km would shift fuel consumption down to 8.57L/100km

Inelastic behavior towards price changes, particularly price increases, is common in markets that provide goods like safety attributes. In general, consumers do not shirk when it comes to paying for improved safety characteristics and features because skimping on such attributes could potentially cost them their life or the life of someone they are close to. This is evidenced by the highly inelastic price elasticity measurements on PINJURY and PSEVEREINJ. The near perfectly inelastic measurement on FUELCAP is potentially explained by the inference that the demand for increased fuel capacity stems primarily from individuals that actually need it and not from a want or desire for the attribute. Greater fuel capacity, all else equal, means fewer trips to the gas station. People who have to drive a long way to work every day or people that live in rural areas may find increased fuel capacity quite attractive. Larger vehicles with greater fuel consumption often have increased fuel capacity. A likely reason for this is to reduce the frequency of refueling.

Explicit Fuel Savings

A comparison of the marginal value of decreased fuel consumption with actual fuel savings will determine if consumers accurately value the fuel savings from decreased fuel consumption (Espey and Nair 2005). The demand for fuel efficient vehicles is largely driven by the rise in fuel prices. The 2005 national average annual retail price of unleaded petroleum was $1.12 per liter in Australia, a 13.7% increase from the 2004 national average (AIP). This jump corresponds to fuel price shock that took place in late 2005 following a disastrous hurricane season in the Gulf of Mexico. As fuel prices rise, improvements in fuel efficiency become increasingly cost effective and the value of fuel savings increase. In the short run, consumers are relatively inelastic in their fuel use with regard to fuel prices due to the complexities involved with forming new travel habits and the high costs of purchasing a more fuel efficient vehicle. Consumers may appear to undervalue the potential fuel savings immediately after an increase in fuel prices. The average annual fuel consumption of passenger vehicles has not fluctuated much over the past decade in spite of substantial improvements in fuel consumption per power output and fuel efficiency of new passenger vehicle fleets because potential fuel savings have been countered by increases in power, size, and weight, by the growth in SUV sales, and increases in the fuel consumption of light commercial vehicles (Australian Transport Council).

The passenger vehicle fleet, comprised of passenger cars and SUVs, makes up over 77% of the current Australian motor vehicle fleet. In 2007, the average age of the passenger vehicle fleet was 9.7 years, a small reduction from the age in 2005 of 9.9 years. Approximately 27% of the total Australian fleet in 2005 was more than 15 years old, hence manufactured before 1991. The average age of the passenger vehicle fleet and the share of the fleet that is more than 15 years old has been decreasing over the last two decades. According to the Australian Transport Center, the average annual distance driven for passenger vehicles is approximately 15,000 kilometers (Australian Transport Council). The average fuel consumption of passenger vehicles is 9.5L/100km. Thus, the undiscounted explicit (actual) fuel savings of a 1L/100km reduction in average fuel consumption for new 2005 passenger vehicles purchased in Australia is approximately $1659. The marginal value of fuel savings estimated by the hedonic price model is equal to $1755 for a 1L/100km, and is higher than the explicit value though not by much. The difference between the explicit and implicit estimates of fuel savings can be tested for statistical difference by subtracting the explicit estimate from the parameter estimate and dividing by the standard error of the parameter estimate. The t value is less than 1which results in a high p-value, thus the null hypothesis of no difference between the implicit and explicit estimates of savings in fuel costs cannot be rejected. The present value of explicit fuel savings for a 1L/100km reduction in fuel consumption equals $1,345, given an interest rate 4%.

The 4.8% increase in consumer marginal willingness-to-pay for a 10% reduction in fuel consumption estimated by the price elasticity of fuel consumption can be similarly analyzed. It was determined in the previous section that a 10% reduction in the mean fuel consumption of passenger vehicles results in a fuel consumption of 8.57L/100km. Based on the elasticity of FCONS, the increased fuel savings of such a reduction should be close to the value of 4.8% of the marginal price of FCONS which is $84.21. This value represents the increase in marginal willingness-to-pay associated with the 10% reduction in fuel consumption. The explicit increase in fuel savings from the 10% reduction in fuel consumption is equal to $88.08. The similar values for the implicit and explicit calculations provide evidence that consumers accurately value the increased fuel savings associated with reduced fuel consumption.

CHAPTER SIX

CONCLUSION

The results of the empirical model estimated in this analysis reveal potentially useful information about the Australian automobile market. The consumer's marginal willingness-to-pay for a 1Liter/100km reduction in fuel consumption was estimated using a hedonic price model of desirable automobile attributes. By estimating the marginal value of fuel consumption, the hedonic regression model revealed the willingness-to-pay for reductions in fuel consumption and the extent to which consumers' accurately value the fuel savings associated with reductions in fuel consumption or improvements in fuel economy. Knowledge of the consumer valuation of fuel consumption can help policymakers gauge the consumer reaction to potential government mandated reductions in fuel consumption and to the provision of subsidies and other financial incentives for increasingly fuel efficient technological innovations.

Previous studies have been largely unsuccessful in their attempts to determine the implicit or marginal price of fuel efficiency. Fuel efficiency is conventionally portrayed to the American public in terms of miles per gallon or fuel economy, while European nations and Australia report the inverse of miles per gallon which measures fuel consumption or liters per one-hundred kilometers. The extent to which miles per gallon presents misleading information to automobile consumers has been the source of several failed estimation attempts and many insignificant estimates of fuel economy in the hedonic analysis literature. Automobile prices are more accurately measured as a function of the inverse of fuel economy, or fuel consumption, because consumers value fuel economy for the fuel savings it provides, thus decreases in fuel consumption have a value of fuel savings directly related to the fuel price per gallon multiplied by miles driven. The results of this analysis indicate that Australian consumers, facing minimal government influence in the automobile market relative to the United States market, accurately value the fuel savings associated with reductions in fuel consumption.

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