8-2016

Consumer Valuation of Fuel Economy in the Australian Automobile Market

Alexandra Dinu Troidl
Clemson University, adinu@g.clemson.edu

CONSUMER VALUATION OF FUEL ECONOMY 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

---

by
Alexandra Dinu Troidl
August 2016

Accepted by:
Dr. Scott Templeton, Committee Chair
Dr. Molly Espey
Dr. Robert Fleck

ABSTRACT

The marginal value that an Australian consumer places on fuel economy is estimated with a hedonic model of prices of new passenger vehicles purchased in 2014. The hedonic model is estimated with 1,802 observations of all sub-models of 105 chosen models that represent 25 makes. Few studies have been focused on this valuation in the Australian market. This study is also unique in that it accounts for three different types of fuel, various vehicle types including hybrids, sports utility vehicles, and sports cars, as well as new technological attributes that enhance a driver's experience. The estimated coefficient for travel cost in the log-linear specification of the hedonic model, indicates that a one-dollar per 100 kilometer decrease in travel cost increases the marginal willingness to pay for a new vehicle 1.69 percent, all else equal. The estimated coefficient for travel cost implies that a marginal consumer would be willing to pay, on average, $AUS 1,427 for the savings in fuel costs from a one liter per 100 kilometer reduction in fuel consumption. In comparison, the present value of directly estimated savings in fuel costs is $AUS 2,116, given a 1.2 percent discount rate. Thus, the marginal consumer seems to undervalue fuel economy. The marginal consumer is also willing to pay a 6.45 percent premium for a hybrid vehicle and a 4.84 percent premium for a sports utility vehicle. An owner's desires to reduce adverse environmental impacts of a vehicle and acquire status for her environmental concerns are motivations that underlie these premia and are separate from a desire to economize on fuel costs.

DEDICATION

This Thesis is dedicated to my family and to my husband, Michael. Without your love and unwavering support of my dreams and aspirations throughout the years, this work would not have been possible.

ACKNOWLEDGMENTS

This study could not have been undertaken without the guidance of my advisor, Dr. Templeton. Dr. Templeton, I thank you for your belief in my abilities and for continuously challenging me to push the limit both inside and outside of the classroom. I am also grateful to my other committee members, Dr. Espey and Dr. Fleck, for their active support of my thesis.

Finally, I would also like to express my thanks to the Federal Chamber of Automotive Industries and their VFACTs team for answering my questions and providing me with the December 2014-year end sales report I needed to complete my analysis.

TABLE OF CONTENTS

Table of Contents (Continued)

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

The Australian automobile industry is currently facing the end of domestic automobile production. This change in the industry has raised questions regarding the future of Australia's automobile standards. Any such policy change would first require a better understanding of the consumer valuation of fuel economy. Thus, in this research, I estimate the value that consumers place on fuel economy through a hedonic price analysis of new car sales in Australia in 2014.

Surprisingly, not many studies have examined the value consumers place on fuel economy in the Australian market. By determining this valuation through the use of new automobile data and a new model specification, a more precise estimation of the marginal willingness to pay for fuel economy is obtained. A comparison of this value with the explicit fuel cost savings of a one liter per 100 kilometer reduction in fuel consumption will show an undervaluation by consumers given the assumptions chosen. This study is also unique in that it disentangles consumer motivations from travel cost through the inclusion of various vehicle and fuel types. While I cannot offer a direct policy recommendation based on these findings, a better understanding of this valuation should lay the groundwork for such future research.

This study will begin by examining the current state of the Australian automobile industry and the current standards debate regarding fuel economy and emissions for new passenger vehicles. Chapter Two will then present an overview of past studies that have attempted to measure this value. Chapter Three will provide an overview of the methodology, data, and variables utilized in this particular case. The final chapters will present the results and recommendations for future study.

The Australian Automobile Market

The Australian automobile industry will cease all production in 2017. This follows from a trend of turbulent history for manufacturers as the automobile industry transformed from one of the most protected industries to one of the least protected industries in Australia. As tariffs and import quotas fell over time, local manufacturers found that they just could not compete with foreign imports (Mellor 2014).

In 1990, Nissan closed its Australian production and began solely importing the models sold in Australia. In 2008, Mitsubishi also followed suit to focus on imports. Starting in 2016, Ford will also stop producing cars in Australia. By 2017 there will no longer be any vehicles produced on Australian soil as Toyota and Australian manufacturer, Holden, will also close their doors. Local producers continue to blame imports and competition for their demise, stating there is simply not enough demand for a particular type of car to sustain a production line.

Traditionally, the standards and regulations facing the Australian car market have been less stringent than those of similarly developed nations (GFEI). The Australian government has been encouraged by various groups including Climate Works Australia and Environment Victoria to update their regulations. Previously any such change in regulation would have placed additional pressure on an industry that was already struggling. These types of policy changes are difficult to undertake as they involve adverse impacts in the short term for consumers and especially for automobile manufacturers. Stricter compliance regulations usually involve higher production costs for local manufacturers, which increase the prices consumers face (James 2013). While soon there will no longer be any local producers in Australia, consumers would still be affected by any changes made.

Australian Fuel Economy Standards

The Department of Infrastructure and Transportation (DIT) is responsible for the management of policy implementation and standards development on emissions and fuel consumption labeling in Australia. They also monitor and manage the Green Vehicle Guide website which serves as a tool that allows consumers to gauge the environmental performance and fuel consumption of their vehicles (DIRD). Currently, the "Australian Design Rules (ADR's), made under Section 7 of the Motor Vehicle Standards Act of 1989, set the standards that each vehicle model is required to meet, prior to their first supply to the market" (James 2013). Presently, Australia does not have any mandatory standards in place to regulate fuel consumption or vehicle emissions (GFEI). In the past, voluntary initiatives have been implemented to address carbon emissions and fuel consumption. These initiatives were brought about from negotiations between the Federal Chamber of Automotive Industries and the DIT. In 2003, these groups implemented a voluntary national average fuel consumption target aimed at reducing fuel consumption to 6.8L/100km by 2010. In 2004, efforts were made to align the fuel consumption standard with a voluntary CO_2 emission target but no consensus was reached. In 2011, the Minister of Infrastructure and Transport in Australia reported an update to the ADR's that would require more stringent emissions standards on all new cars sold in Australia. The standards would be the same as those required of Euro 5 standards starting in 2013 and Euro 6 starting in 2017 (James 2013). The voluntary standards have succeeded in gradually improving fuel consumption and carbon emissions over time, however, the stated targets have not yet been met (GFEI). In 2014 the average fuel consumption of passenger vehicles in Australia was 10.7 L/100km (ABS). The national average carbon emission for Australian vehicles in 2014 was 187.7 g/km of CO_2 (FCAI 2014 National Report). With the end of Australian automobile manufacturing in sight, many questions have been raised regarding the effectiveness of the current policies. In October of 2015, the government placed The Motor Vehicle Standards Act of 1989 under review until further work is done to assess the best policy going forward given the new nature of the automobile industry (DIRD).

Some of the current discussion has centered around creating a mandatory standard that is aligned with the standards of the European Union, the United States, or somewhere in between (James 2013). When deciding if Australian standards should more closely resemble European or U.S standards, an issue that legislators must consider outside of which target is most important, is that of which region Australia most closely resembles. Australian drivers seem to be more closely in line with American drivers. Both drive longer distances and more often than their European counterparts, who have more of an opportunity to use public transportation. Australians also tend to have larger cars with larger engines than do Europeans (James 2013).

In the end which policy to adopt is beyond the scope of this paper. The standards of both the E.U. and the United States would represent significant cuts for Australian consumers. The proposed U.S Standards set in place by the Obama Administration in 2011 required an average miles per gallon for cars and trucks of 40.1 which would equate to roughly 5.87L/100km. In comparison, the EPA's standards were 163g/km while the E.U requires that passenger vehicles not surpass 130g/km of CO_2 which started in 2012 (James 2013). A deeper understanding of consumer behavior would be needed in order for the government or any organization to decide whether Australia should adopt different standards during this time of change in the industry. Many organizations claim that if Australian consumers only made different choices whether by buying more fuel efficient cars or more environmentally friendly cars, Australia could drastically improve fuel economy and reduce emissions (James 2013). Whether or not consumers actually choose to purchase more fuel efficient vehicles depends on how they value fuel economy. A better understanding of this valuation could greatly assist governments in understanding consumer demand thereby assisting policy makers with these types of decisions in the future.

CHAPTER TWO

PREVIOUS LITERATURE

There have been many studies completed on the American automobile industry due to the potential policy insights of understanding how consumers value fuel economy. In 1974 Sherwin Rosen established the hedonic method and many economists have since utilized his method to expand on automobile price analysis. This paper too is based on the methods he developed. An interesting topic covered in an overview of the literature by Helfand and Wolverton (2011) is that of the “Energy Paradox”. This refers to the gap between what consumers would save from the employment of mechanisms for energy conservation and the (presumably lower) amount they are willing to pay for those mechanisms. In other words, consumers appear to “undervalue” energy conservation. When it comes to fuel consumption there is much debate on whether this paradox holds.

In a report released by the EPA in 2010, Greene provides an excellent review of the most significant results on fuel economy using hedonic methods. The outcomes of some of the most relevant studies are summarized below.

Arguea, Hsiao and Taylor (1994) used 18 years of automobile data from 1969 to 1986 to estimate the marginal willingness to pay for fuel economy. Utilizing ordinary least squares, a linear hedonic price function, and gallons per mile as the measure for fuel economy, they find that consumers undervalue fuel cost savings when comparing the marginal willingness to pay for fuel economy with the discounted fuel cost savings. They find that the willingness to pay is 5-10 percent of the discounted savings for every year except the last year in which the willingness to pay was 46 percent of the discounted lifetime savings.

Espey and Nair (2005) analyzed 2001 model year cars, and included many vehicle characteristics relating to size, power, performance, safety, comfort, and reliability. In their single stage regression corrected for heteroskedasticity, the measure of fuel consumption was the inverse of fuel economy, or gallons per mile. The authors concluded that consumers fully value lifetime savings.

McManus (2007) analyzed 2002 models and a variety of car characteristics but rather than analyzing fuel economy separately, "travel cost" was the preferred variable to measure fuel consumption. McManus divided the price of fuel by miles per gallon to obtain a figure measured in dollars per mile traveled. As expected, he found a negative coefficient on travel cost, which implied that a one-dollar increase in the price of travel will reduce the willingness to pay for fuel economy by $768. When comparing with the discounted fuel cost savings, McManus finds a slight undervaluation by about 10 percent but concludes that consumers are fully valuing fuel cost savings.

Fan and Rubin (2009) analyzed passenger cars and light trucks and utilized a two stage hedonic method, miles per gallon as the measure of fuel economy, and a log-log functional form in their analysis. They find that the marginal willingness to pay for a 1 mile per gallon increase in fuel economy was $208 for cars and $233 for trucks. This leads them to conclude that consumers are on average undervaluing fuel economy in comparison to undiscounted lifetime savings of $823 for cars and $1,461 for trucks. When measuring the willingness to pay for fuel economy separately for each vehicle class, they obtain mixed results, obtaining a negative willingness to pay for fuel economy in some classes. While they find no direct explanation for this, they believe that in some cases other features such as luxury attributes may outweigh consumer desire for fuel economy.

Fifer and Bunn (2009) analyzed a time interval from 1996-2005 and also utilized the inverse of fuel economy (gallons per mile). They estimated different coefficients for the fuel consumption of passenger cars, SUVs, vans, and pickup trucks while also controlling for manufacturer fixed effects. Using this method, they found the present discounted value of fuel cost savings to be $167.42 for cars, $193.97 for pickup trucks, $194.67 for vans, and $197.78 for SUVs. They find that consumers are under valuing the fuel cost savings for cars and SUVs but grossly over valuing the fuel cost savings for vans and pickup trucks. They conclude this mixed result could come from a difference in use of the various vehicles. Vans and trucks are typically driven 20 percent more so that a decrease in fuel consumption should be valued higher. When they combined the vehicle types and only created one measure of fuel consumption, they obtained a similar result as Espey and Nair.

Allcott and Wozny (2010) use a nested logit model and use variation in fuel prices to determine preferences for fuel economy as sales of more fuel efficient vehicles should increase when gas prices are high. They find that the consumer willingness to pay for fuel economy is 60 percent of the savings using a discount rate of 9 percent When utilizing higher rates such as between 18-27 percent they find that consumers fully value fuel cost savings. Similarly, Sallee, West, and Fan (2009) also find an undervaluation by 80 percent of the fuel cost savings when using a discount rate of 5 percent. However, they too when using a higher discount rate find a “full valuation”. From these results it is apparent that the discount rate used can make a big difference on apparent consumer valuation of fuel economy.

Other conclusions regarding the “Energy Paradox” involve the idea of “bounded rationality” introduced by Sanstad and Howarth (1994). Bounded rationality refers to consumers making mistakes when evaluating fuel consumption. This mistakes could arise simply because they aren’t capable of making the appropriate calculations thereby resorting to “simple rules of thumb” that may not be entirely correct in actuality.

Helfand and Wolverton (2011) report that some of this variation and lack of consensus on consumer valuation is due to the different models and assumptions utilized, however, this variation could also be due to the fact that fuel economy is not only difficult to estimate but there is also a high probability of its correlation with other variables. The difficulty in estimation ensues from the fact that if all “relevant” variables are included there may be evidence of collinearity, and if some are omitted than the results could suffer from omitted variable bias. In practice most research attempts to discover the most important variables and by including them the hope is that the variables that were omitted do not bias the results too heavily.

To my knowledge, not many studies have statistically evaluated a status or environmental effect associated with automobile purchases through a hedonic price analysis. One approach that was particularly relevant to this study was completed by Alberini, Bareit, and Filippini (2014). In this study they performed a hedonic price analysis on cars sold in Switzerland from 2000 to 2011 to evaluate the willingness to pay for fuel economy as well as examine if there is a premium on fuel efficient cars due to the labeling requirement. This study is of particular interest as the Swiss market does not have their own producers; all cars sold are imported which, will soon be the case in Australia. Their results suggest that qualifying for the top rated label results in a 6-11 percent increase in price. These findings may have additional implications for the Australian market which has also implemented a labelling system. The Australian label is not as complex as the Swiss label which rates vehicles, from best to worst, based on their fuel consumption. One alternative approach to the econometric models that examined consumer motivations for their automobile purchases was undertaken by Turrentine and Kurani (2006). The authors explored how consumers value fuel economy by conducting a series of surveys on California households. Their results showed that consumers may not behave according to economic theory and while they value fuel savings, they do not have the capability to accurately calculate their expected fuel savings nor do they even attempt to do so. The research suggests that while fuel economy is valued it is more so valued for the signal that it sends to car manufacturers and to others about their environmental concern and their lifestyle habits.

While much research has been done on the American automobile market, not much has been completed on the Australian market. In Perkins (2009) a hedonic price analysis of 2005 model year vehicles was conducted to examine the marginal willingness to pay for fuel consumption in the Australian market (Perkins 2009). The study pioneered the use of two safety variables based on a report from Monash University on crash data. The variables, probability of injury given an accident and probability of severe injury given an injury, will also be utilized in this study. Similar studies in the United States have used braking distance and crash test ratings as a measure of safety (Espey and Nair 2005). Australia has similar crash test ratings for new cars, published by the Australian New Car Assessment Program (ANCAP), which rates vehicles on a 1-5 scale based on performance in crash results with a score of 5 being the best safety rating (ANCAP 2016). These ratings however, are not comprehensive and do not cover all makes and models sold in 2014 only accounting for 60 percent of the vehicles included in the dataset. In order to compare all vehicles in the dataset based on one safety rating, the safety variables utilized in the previous study were also utilized in this study.

Further research on the consumer valuation of fuel economy would be an important step in understanding consumer behavior and how to implement new standards in the future. Through a more precise estimation of the hedonic price function, this research aims to uncover a more accurate measure for the consumer valuation of fuel economy in Australia.

CHAPTER THREE

METHODOLOGY

Model

The model used in this paper is based on Rosen's methodology for hedonic price analysis. The purchase price of a new vehicle reflects not only the benefits that consumers will receive from transportation but also includes the value that they place on the bundle of attributes that come standard with each vehicle. Some of these characteristics include but are not limited to performance, size, safety, fuel characteristics, and technological features. The price of any one vehicle is a function of each of its characteristics and can be represented as:

$$P_{Auto} = P(C_1, C_2, C_3, \dots C_k)$$

Where each C_k represents a certain attribute of the vehicle. Each of these characteristics carry their own implicit prices that can be found in the equilibrium interactions between consumers and producers in the market. Taking the partial derivative of the equilibrium hedonic price function with respect to a certain attribute reveals the implicit marginal vehicle price of that attribute.

$$\frac{\partial P_{Auto}}{\partial C_k} = p(C_k)$$

This implicit price, $p(C_k)$, represents the marginal consumer's marginal willingness to pay for the attribute. This type of analysis can be employed to analyze anything whose price depends on several characteristics, however, it will be especially useful in determining the implicit value that consumers place on fuel economy and other automobile characteristics in this study.

The particular model utilized in this study is estimated with ordinary least squares and a log-linear functional form. The hedonic price function is of the following specification:

$$\mathrm{Ln(PRICE\,)_i} = \alpha_{\,0} + \beta_0\mathrm{(PEAKPOWER)_i} + \beta_1\mathrm{(WHEELBASE)_i} + \beta_2\mathrm{(KERBWEIGHT)_i} + \beta_3\mathrm{(PRINJGACC)_i} + \beta_4\mathrm{(PRSEVGINJ)_i} + \beta_5\mathrm{(FUELCAPACITY)_i} + \beta_6\mathrm{(TRAVELCOST)_i} + \beta_7\mathrm{(DIESEL)_i} + \beta_8\mathrm{(HYBRID)_i} + \beta_9\mathrm{(SUV)_i} + \beta_{10}\mathrm{(SPORTS)_i} + \beta_{11}\mathrm{(NAVIGATION)_i} + \beta_{12}\mathrm{(CAMERA)_i} + \beta_{13}\mathrm{(BLINDSPOT)_i} + \beta_{14}\mathrm{(COLLISION)_i} + \beta_{15}\mathrm{(LANEDEPART)_i} + \delta'\mathrm{(MAKE)_i} + \varepsilon_i$$

where δ' is a 1 x M vector of the coefficients for the fixed effects of the make of the i-th vehicle in the regression. These observations were also weighted based on the total number of each sub-model sold. The weighting of the variables results in robust standard errors being estimated in the regression.

Data

The vehicles selected for the sample come from the December 2014 report, called VFACTs, which is compiled by the Federal Chamber of Automotive Industries in Australia (FCAI). This report contains information on the total quantity of vehicles sold by model, make, and market segment. Passenger cars and sport utility vehicles (SUVs) are classified into some of the following segments: light, small, medium, large, upper large, people movers (minivans), sports, small SUV, medium SUV, large SUV, and upper large SUV (FCAI).

Various models were selected such that the most popular vehicles would be represented in the study. Every sub-model of each model that had a market share of at least 10 percent in the previously listed segments was included in the dataset. A few additional models that did not meet the 10 percent criterion are also included in the data because they were included in a previous dataset (Perkins 2009). After these criteria were applied, data on 25 different makes and 105 models remained. This resulted in 1,802 observations of all of the sub-models of each model collected. This represents 77.6 percent of all passenger cars and SUVs sold in 2014 (FCAI). There are very many models in the market that consumers can choose from. Even by accounting for almost 80 percent of all vehicles sold, the sample only represents approximately 51 percent of all makes and 33 percent of all models sold in 2014 (FCAI).

Data about vehicle prices and characteristics were gathered from the RedBook Australia website, published by Automated Data Services Pty Ltd. The Redbook information is utilized by consumers, private businesses, and the government (Redbook). Safety ratings are taken from a 2014 report compiled by Monash University's Accident

Research Centre on safety ratings from police reported crash data from 1987-2012. These safety data were chosen under the assumption that consumers purchasing new vehicles in 2014 will use the safety data from the update issued in 2014 to make their purchase decision. On occasion, the specific model may not have had safety data reported in the 2014 report in which case the Makes "Other" crash data were utilized. For example, crash data for the Mazda CX-5 was not included in the 2014 report. However, the 2014 issue of the Monash study did report crash data information for "Mazda Others". While consumers may not have been able to reference the 2014 report for the specific model they were interested in purchasing, it is reasonable to assume that some safety information would have been available to them at the time of their purchase decision.

The fuel price information was compiled from a report published by the Australian Institute of Petroleum (AIP) on retail prices at the pump for petrol and diesel fuel prepared by ORIMA Research Pty Ltd. The report includes regional and national level data for Australia. The national average price data reported by the AIP is a weighted average of the fuel price in all of the regions, where the weights are based on the number of vehicles driven in each region with the respective fuel type. The average national price of petrol fuel in 2014 was 148.8 cents/liter. For Diesel fuel, the national average price in 2014 was 156.8 cents/liter. In order to include the vehicles that run on LPG (liquefied petroleum gas) fuel in the dataset, the average LPG fuel price in 2014 was also included. This price was taken from a report published by the Royal Automobile Club of Queensland. The aim of the Club's report is to provide an overview of fuel price movements and is primarily focused on the Brisbane market. The average price of LPG in Brisbane in 2014 was 82.5

cents/liter and will serve as a proxy for the national fuel price as LPG fuel was not featured in the AIP report.

Vehicle Characteristics

Redbook publishes the manufacturers recommended sales price (Australian dollars) for each new vehicle. The prices of new vehicles in the dataset range from $14,990 for the Honda Jazz, Mazda 2, and Toyota Yaris to $466,900 for the Porsche 911, with the average price of a new vehicle at approximately $64,215.23. As can be seen from these statistics, there are a wide range of prices in the dataset and they are not normally distributed. Many of the cars fall under the $100,000 mark, however, there are several vehicles in the upper large and sports categories that skew the data. The dependent variable was transformed to the natural logarithm of price to better fit the data. This allows for a more normally distributed price variable. (See Figures 1.1 and 1.2)

The explanatory variables used in the regression can be broken down into several categories that consumers care about. These categories include performance, size, safety, fuel related characteristics, and technological features.

Performance is oftentimes associated with bragging rights and perceived status. The performance variable used in this regression is Peak Power (PEAKPOWER), which is measured in kilowatts and represents the maximum engine power of the vehicle (Perkins 2009). Generally, the higher the power, the faster one can expect a car to accelerate (Drive 2016). This feature is expected to have a positive coefficient because more powerful vehicles should be valued higher by all consumers.

WHEELBASE is measured horizontally from the center of the front wheel to the center of the back wheel and is represented in millimeters (Redbook). This measurement represents the floor space of a given vehicle. A longer wheelbase adds to the comfort and carrying capacity of a vehicle, resulting in a positive expected coefficient.

KERBWEIGHT represents the total weight of the vehicle in kilograms. This size measure includes the total weight of all parts and fluids needed to run the vehicle excluding passengers or cargo. Kerb weight is used to measure size as "curb weight is likely the best indicator of size, as both length and width are one-dimensional and wheelbase can vary across similar size vehicles depending on vehicle size" (Espey and Nair 2005). This variable is expected to have a positive coefficient in the regression.

The safety variables utilized in this study are probability of injury given an accident (PRINJGACC) and probability of severe injury given an injury (PRSEVGINJ). The probability of injury is the ratio of the number of injured drivers to the number of involved drivers in an accident. This variable is expected to have a negative coefficient. As the probability that a driver is injured given that they were involved in an accident increases, the less safe the vehicle's perception, thereby becoming less desirable to consumers. The probability of severe injury given an accident is the ratio of the number of severely injured drivers to the number of injured drivers. PRSEVGINJ can be seen as the additional cost or penalty from having an unsafe vehicle also resulting in a negative expected coefficient on this variable.

$$PRINJGACC = \frac{\#\ of\ injured\ drivers}{\#\ of\ involved\ drivers}$$

$$PRSEVGINJ = \frac{\#\ of\ severely\ injured\ drivers}{\#\ of\ injured\ drivers}$$

FUELCAPACITY refers to the amount of fuel, measured in liters, that a vehicle's tank can hold. This variable affects the convenience and time costs of refueling and is expected to have a positive coefficient in the regression. All else equal, the greater the fuel capacity, the longer that a consumer can go before stopping to fill up for gas.

TRAVELCOST is a variable that represents the monetary cost of consuming fuel to travel a given distance. The specification allows for an easy estimation by providing one measure for various types of vehicles in the dataset (Diesel, Petrol, and LPG). The travel cost measure in this study is composed of the average price of the respective fuel type of a given car in 2014 multiplied by the combined fuel consumption in liters per 100 kilometers. Every vehicle that is sold in Australia undergoes testing under various driving conditions to obtain the fuel consumption that is marketed with the vehicle. The testing releases three measures of fuel consumption: urban, extra urban, and the combined fuel consumption measure. Urban fuel consumption represents the conditions found in stop and go traffic with approximate speeds of 19 km/hour. Extra urban fuel consumption is meant to mimic highway driving with higher approximate speeds of 63 km/hour and peak speeds of 120 km/hour. The combined measure is derived from a weighted average of the two measures that is meant to represent the fuel consumption a consumer should expect with average vehicle use (GVG). The price of fuel was reported in cents per liter by the AIP. For the purposes of this study it has been converted to dollars per liter. When combined to form the Travel Cost variable, the units result in a measure of Australian dollars per 100 km.

Travel Cost is expected to have a negative coefficient. All else equal, as the cost of travel increases, the willingness to pay for the vehicle should decrease.

*TRAVELCOST = Price of Fuel*Average Fuel Consumption*

To measure status and capture any characteristics not being directly measured by the other variables, this study also controlled for various vehicle types. These variables may signify certain desirable features to consumers, as well as about the consumers who purchase them. The vehicle types are diesel, hybrid, SUV, and sports and they should each have a positive coefficient.

DIESEL represents whether the car has a diesel engine (Redbook). This variable represents reliability. Diesel engines are known to last longer, and require less maintenance and repairs than petrol engines over time (Edmunds).

HYBRID represents a vehicle with an engine that runs on both electricity and fuel (Redbook). Hybrids typically offer much higher fuel economy than petrol vehicles, however, their main allure is that they are environmentally friendly and produce less greenhouse gas emissions. As fuel consumption is already being picked up by the other variables, any additional premium that a consumer would pay on a hybrid vehicle should come from the fact that hybrids emit less greenhouse gas emissions. The premium may also communicate something about status. Many individuals buy hybrids to improve their lifestyle and show to others that they care about the environment (Turrentine and Kurani 2006).

SUV stands for sports utility vehicle and is often associated with those who enjoy outdoor activities and sports. SUV's have become particularly popular in the Australian market due to the "versatility of the vehicles" (FCAI 2014 Annual Report). In 2014, SUV sales increased dramatically to now account for 31.7 percent of new vehicle sales, while other types of passenger cars only account for 47.8 percent of total new car sales.[1] This increased interest in SUVs is expected to continue through 2015 and beyond (FCAI 2014 Annual Report). The inclusion of this variable is expected to pick up some of the positive, popular characteristics of SUVs that have increased their demand that otherwise wouldn't have been measured by our data.

SPORTS represents a sports vehicle as classified by FCAI. The FCAI classifies cars as sport if the car is a coupe, convertible, or roadster. This type of car can also be an indicator of lifestyle or luxury status.

The technology variables in this study are NAVIGATION, CAMERA, BLINDSPOT, COLLISION, and LANEDEPART. These types of features have not been included in previous studies. They represent a wide variety of convenience and "smart" features that consumers care about. Each of these variables is a dummy variable, representing whether these features came standard on each respective model. These features were chosen as they have become more prevalent in higher priced brands and due to the fact that they can be considered "luxury features". The Navigation feature is "an electronic device that utilizes a Global Positioning System to locate the vehicle on a predetermined map" allowing consumers easier navigation to their destinations (Redbook).

[1] The remaining 20.5 percent of new vehicles sales come from sales of light and heavy commercial vehicles. As the consumers that purchase these types of vehicles are expected to have different motivations from consumers that purchase passenger vehicles and SUVs, these types are not included in the analysis.

The Camera feature refers to the inclusion of a back up camera, generally on the back bumper of a vehicle, that allows for better overall driver awareness, safety, and convenience when parking or leaving a parking spot.

In recent years, additional luxury features such as blind spot monitors, collision alerts, and lane departure warnings have been added to new vehicles to enhance the safety of the passengers. BLINDSPOT will "alert driver of imminent collision by checking the distance and spread of objects in adjoining lanes" (Redbook). Similarly, the COLLISION feature will alert the driver to objects in their respective lanes. LANEDEPART is meant to "assist the driver to remain within their lane by providing a warning when the car is nearing a lane marker" (Redbook). Each of these variables is expected to have a positive coefficient as they enhance the safety and driving experience of a vehicle.

Finally, a dummy for the make of each vehicle was utilized to control for comfort, reliability, luxury, and other features not measured directly by the data. Toyota served as the base make because it had the most vehicle sales in 2014. Toyota sold 203,501 vehicles out of the approximately 1.1 million total vehicles sold in 2014 (FCAI). The observations were also weighted in the regression by the total number of each sub-model sold in 2014. The VFACTs report provided sales information for each model sold in 2014. To estimate the quantity of each sub-model sold, the number of each model sold was divided by the number of the model's sub-models that were offered in 2014. The descriptive statistics of the variables are shown in Table 1.1 and 1.2.

CHAPTER FOUR

EMPIRICAL RESULTS

The results of the first stage analysis reveal the implicit marginal values of each of the characteristics featured in the regression. With a log-linear specification the results are interpreted as follows: a one-unit increase leads to a percentage increase or decrease in the recommended sales price of a new vehicle *ceteris paribus.* The regression as a whole is statistically significant with an F statistic of 1275.46. The R^2 is .9471 signifying that the explanatory variables explain 94.71 percent of the variation in the dependent variable, logprice. All but one coefficient has the anticipated sign and the majority of the variables are statistically significant at the 95 percent confidence level. The only variables that were not statistically significant were WHEELBASE, SPORTS, and PRINJGACC. WHEELBASE was also the only variable whose coefficient did not have the expected sign. An overview of these results can be found in Table 2.1.

In terms of performance, PEAKPOW shows that an increase in one kW of power would result in a 0.34 percent increase in the price of a new vehicle, all else equal. While this may sound like a small magnitude, it is not surprising. Unless, the vehicle is at the threshold for being marketed as different type of vehicle, the difference in price between a vehicle with 155kW and 156kW of power should not be too different.

The same can be said for KERBWEIGHT. A one kg increase in the kerb weight of a vehicle would lead to a .06 percent increase in the price of a new car all else equal.

Similarly, FUELCAPACITY also had a smaller magnitude of 0.18 percent increase in price for a one-liter increase in fuel capacity. This also seems reasonable as this is not a feature that is usually heavily marketed by manufacturers. In terms of safety, an increase in the probability of a severe injury given that an individual was injured (PRSEVGINJ) would result in a 11.11 percent decrease in the price of a car, all else equal.

TRAVELCOST is negative and statistically significant as expected. A one dollar per 100 kilometer increase in travel cost reduces the willingness to pay by approximately 1.69 percent, all else equal. In the next section we will assign a dollar figure to this valuation on fuel economy in order to provide a comparison with the explicit fuel cost savings of a 1L/100km reduction in fuel economy to determine whether consumers fully value fuel cost savings.

When it comes to vehicle type the results were as follows. The coefficient on HYBRID was positive and significant as expected. The outcome suggests that consumers are willing to pay 6.45 percent more in the price of the car to own a hybrid. As fuel economy is already being measured in the regression, this implicit value of 6.45 percent should be attributed to the lower greenhouse gas emissions and the status associated with owning the vehicle. Consumers were willing to pay an implicit value of 4.84 percent more in the purchase price of a new vehicle to own an SUV. The premium placed on owning DIESEL vehicles was valued at a 6.44 percent increase in the purchase price of a new car.

All of the technological features were valued rather highly in the study. NAVIGATION had an implicit value of a 14.01 percent increase in the price of a car. The

CAMERA feature was valued at an increase of 6.49 percent in purchase price. The BLINDSPOT monitor was valued at a 7.39 percent increase in price. The COLLISION Alert was valued at a 4.08 percent price increase. Finally, LANEDEPART was valued at a 6.88 percent price improvement.

Typically, not much is mentioned in regards to the fixed effects utilized in a study however, it is interesting to note that the coefficients on the make dummies all have the sign and significance one would expect when using Toyota as the base group. Ford, Holden, Jeep, Mazda, and Chrysler are all valued less favorably than Toyota. While the luxury brands Audi, BMW, Land Rover, Mercedes-Benz, Volkswagen, Volvo, Lexus, Porsche, Mini and a few others such as Honda, Mitsubishi, Renault, Subaru, and Peugeot were valued higher than Toyota. Other Asian car brands were found to be statistically indistinguishable from Toyota among which are Nissan, Hyundai, Kia, Ssangyong, and Suzuki.

CHAPTER FIVE

DISCUSSION

Insignificant Variables

A surprising outcome was the fact that the variable SPORTS was insignificant. This could be due to the fact that Australian consumers prefer other types of vehicles. Clearly diesel, hybrids, and SUVs seem to be more popular. In the dataset SPORTS vehicles only accounted for 4 percent of the entire vehicles sold. Additionally, it could be the case that the only difference between SPORTS and other passenger cars is the body style. Body style could be a feature that does not affect the purchase decision significantly.

For WHEELBASE, it could be the case that the measurement is also correlated with turning radius. If wheelbase is also indicative of turning radius, a larger turning radius should be less desirable in terms of maneuvering a vehicle. This effect could push the implicit value of wheelbase down and introduce more "noise" into the estimation. While the main value is positive because of the increase in vehicle size, the net effect could lead to inflated standard errors thereby leading to a statistically insignificant variable.

The lack of statistical significance for the probability of injury given an accident (PRINJGACC) was also unexpected. One would expect that safety would be highly valued by consumers. A possible reason for this outcome could be due to the fact that "injury" is vague especially in comparison to an additional measure titled probability of "severe injury" which has a harsher tone. All consumers should want to avoid a severe injury if at all possible. However, an increase in the probability of injury may not be a deterrent in their purchase decision. Another possible explanation could be due to the fact that the consumers did not actually have access to this safety data, or that given access the search costs, time, and energy spent to find these statistics would be less important to them than the other features that were more readily marketed on each model.

Other Results

While the first measure of safety was not statistically significant, PRSEVGINJ was statistically significant. This could be indicative of a certain safety threshold for consumers. While the first measure may either be inaccessible or unimportant to a consumer, if the safety rating of a car falls below a certain threshold it could severely impact their purchase decision and their willingness to pay for that specific unsafe vehicle.

The implicit value of the SUV variable should be interpreted as the value consumers place on the SUV lifestyle, as size and fuel economy are already being measured. The same study by Turrentine and Kurani (2006) brought out this motivation among middle and upper-middle income households that liked having at least one SUV that was large enough for “children, dogs, vacation baggage, shopping items, and recreation activities”. While the estimated value seems low compared to the actual price difference between SUV’s and other types of vehicles, it should be interpreted as the premium paid for the motivations listed above.

The estimated value of DIESEL vehicles could be an indicator of several factors. As mentioned before, diesel engines can signal reliability. Diesel vehicle’s also have higher resale values than comparable cars that run on petrol. The total cost of ownership is also lower for diesel cars even after accounting for depreciation, fuel, repairs, fees, taxes, insurance, and maintenance when compared to a petrol engine (NAP). This implicit value of 6.44 percent could reflect value of the additional reliability that consumers may associate with diesel engines.

This implicit value of the NAVIGATION feature seems high but it could be the case that the Navigation system is also correlated with other desirable features. For example, models that have navigation systems may also have a sound system, or voice recognition technology, or other smart technological features that are desirable to consumers. As such, the valuation could also be picking up other effects.

The CAMERA, BLINDSPOT, COLLISION, and LANEDEPART features could each possibly signal status thereby explaining some of the reason that they were also valued so highly. As with some of the other features already described, while the technology may be valued for its own sake or for the additional safety, all of these features also enhance the driving experience and could serve for purposes of bragging rights among friends and coworkers. Additionally, these features may be picking up the fact that they could often be "bundled" by manufacturers with other improvements in the vehicle such as horsepower, comfort, and other luxury features. Studies also mention that consumers have started judging the utility of vehicles differently than they did in the past. J.D Power even changed their Initial Quality Survey (IQS) to account for the evaluation of these technologies. The results of the survey showed that perceived reliability of a car will decline if technology does not enhance "driver experience" (NAP).

Travel Cost

If the fuel-cost of travel decreases one-dollar per 100 kilometers, the recommended sales price of a vehicle increases 1.69 percent, regardless of the initial travel cost or price of the vehicle, because such a constant percent effect is an implicit assumption in my specification of the log-linear model. However, when the constant percentage effect is translated to dollars, the effect of travel cost on a vehicle's price varies. In particular, the negative effect of travel cost on a vehicle's price increases in absolute value as the price of a vehicle increases.

Consider SUVs. These types of vehicles are the most fuel inefficient vehicles in the dataset. SUVs also tend to be higher priced. In the dataset SUVs have an average price of $68,292 compared to an average price $62,530 for all other types of cars. As the specification of the estimated model implies, the positive impact of an improvement in fuel economy on the price of an SUV is larger the higher is the price of such a vehicle not because the SUV is relatively fuel consumptive. In other words, the reason in the specified model for a relatively large estimated marginal willingness to pay for an improvement in the fuel economy of an SUV must be due to its relatively high price not its relative fuel inefficiency. In contrast to this argument is the argument of Gramlich (2008), as paraphrased by Helfand and Wolverton (2011): a consumer of an SUV has the highest willingness to pay for an improvement in fuel economy because the vehicles are relatively fuel inefficient.

While the findings so far have been interpreted in terms of the implicit consumer valuation of travel cost, the findings also have implications for the valuation of fuel consumption. This valuation can be obtained by multiplying the estimated coefficient of travel cost from the regression with the respective fuel price of each vehicle type. This gives the approximate implicit valuation of a decrease in fuel economy or an increase in fuel consumption. By utilizing this approach, the results suggest that a one liter per 100 kilometer increase in fuel consumption results in an approximate 2.51 percent decrease in the willingness to pay for vehicles that run on petrol, a 2.65 percent decrease in the willingness to pay for diesel vehicles, and a 1.39 percent decrease in the willingness to pay for LPG vehicles. The effect of an increase in fuel consumption on the willingness to pay varies due to the differences in fuel price across vehicle types.

The "Hybrid Effect"

Other interesting results that arose from this model are those that correspond to status. In this study, I estimated a "hybrid effect" corresponding to the 6.45 percent premium consumers are willing to pay for hybrids. As many vehicle attributes were already accounted for in the model, such as travel cost, size, safety, and technological features, the value I estimate should isolate the signal that consumers want to send to others about their lifestyle. This signal is one of environmental concern. This is further supported by the research done by Turrentine and Kurani (2006). In the survey results, the hybrid owners interviewed were much more likely to discuss the environmental impact as reasons for purchasing a hybrid than fuel consumption. The authors even noted that the respondents in the survey seemed proud of their commitment to the "hybrid" lifestyle. They saw themselves as living "lighter" by consuming fewer resources and they were attracted by the technology and the lower emissions. In a similar paper by Kurani, Turrentine, and Heffner (2008), hybrid owners responded to surveys that they bought hybrid vehicles mainly for ideological values, not to save money on fuel. One individual in the study even mentioned buying the hybrid in order to send a signal to car manufacturers about the types of cars they should continue producing. This implicit value of 6.45 percent is that which consumers place on the signal that owning a hybrid sends to others about their lifestyle and environmental concern.

Explicit Fuel Cost Savings

To determine the explicit fuel cost savings that a consumer would enjoy, several assumptions were made. First, and most important is the fuel price used. It would be very difficult for a consumer to determine with complete accuracy an expected future fuel price over time. As in Fifer and Bunn (2009) it is assumed the consumers believe fuel prices to be a "random walk", such that the best predictor of future fuel prices over the life of a new vehicle are current fuel prices. For this reason, the average fuel prices of diesel, petrol, and LPG that were used in the hedonic analysis are also used in these calculations. The other assumption made is regarding kilometers traveled in a year and average lifespan of a newly purchased vehicle. According to Australian Bureau of Statistics, the average kilometers traveled in 2014 by passenger vehicle drivers was 13,700 kilometers and the lifespan of a new car was 10.7 years.[2] Finally, the last assumption made was deciding on an appropriate discount rate. The discount rate chosen for these purposes was 1.2 percent. In 2014, the

[2] For this calculation 11 years was the assumed average lifespan of a new vehicle.

interest rate on a long term government bond in Australia was 4.7 percent and the inflation rate based on the CPI was 3.5 percent (OECD 2016). To obtain an approximate adjusted interest rate, the inflation rate was subtracted from the government bond rate to obtain a discount rate of 1.2 percent.

The undiscounted savings using each of these parameters and assuming a 1L/100km reduction in fuel consumption were $205.34 a year for petrol drivers, $216.38 for diesel drivers, and $113.85 for LPG drivers. The discounted lifetime fuel cost savings were $2,104.27 for petrol, $2,217.40 for diesel, and $1,166.68 for LPG. For a direct comparison with the consumer valuation of these savings, a weighted average of these numbers based on the total number of each vehicle type sold was calculated to obtain the average lifetime discounted fuel cost savings. This amount was found to be $2,116. The calculations used to derive these values are highlighted below.

Undiscounted Fuel Cost Savings

$$B = Price\ of\ Fuel * \Delta FuelConsumption * Avg.Km\ Travelled$$

- "B" is measured in $/year and represents the undiscounted fuel cost savings for vehicles of each type of fuel.

Discounted Lifetime Fuel Cost Savings

$$Discounted\ Fuel\ Cost\ Savings = \left(\frac{B}{r}\right) * (1 - \frac{1}{(1+r)^t})$$

- "r" represents the discount rate, assumed to be 1.2 percent
- "t" represents the average lifespan of a given vehicle-11 years
- This calculation was done for vehicles of each type of fuel (petrol, diesel, liquefied petroleum gas)
- A weighted average of each of these lifetime savings was taken in order to obtain the average discounted lifetime fuel cost saving used in the study. Weights were

determined based on the total number of each type of car (petrol, diesel, and liquefied petroleum gas in sample)

Due to the way that the hedonic model was estimated, a few adjustments were needed in order to have a direct comparison with the consumer valuation of these figures. First, the predicted prices were obtained using the coefficients estimated in the first stage regression for each of the models in the study. Second, a new fuel consumption variable was created by subtracting one from the average fuel consumption variable already in the dataset. This new fuel consumption variable was then utilized to create a new travel cost variable. Doing this allowed for an exact reduction in the travel cost variable by 1L/100km. Finally, the coefficients from the first stage regression were used to again predict the prices of new vehicles, however, the newly created travel cost variable was used rather than the old one. Having these two measures of the predicted prices defined an implicit marginal willingness to pay for a 1L/100km reduction in fuel consumption. This number was found to be approximately $1,427 dollars across all vehicle types. When examining the ratio of the implicit hedonic price of fuel economy to the present discounted value of fuel cost savings, this study finds that marginal consumers value approximately 67 percent of the discounted fuel cost savings. Stated differently, this analysis finds evidence of a 33 percent undervaluation of the potential fuel cost savings from an improvement in fuel economy.

Based on the assumptions made to arrive at these estimates, consumers are on average undervaluing the potential fuel cost savings from a 1L/100km reduction in fuel consumption at low discount rates. Additional calculations revealed that the marginal consumers would fully value the lifetime expected fuel cost savings if the discount rate were approximately 8.68 percent.

This provides at least minor evidence of the “Energy Paradox”. Primarily, this could result because consumers may not be very well versed in the actual benefits of a reduction in fuel consumption and they may not have all of the information needed to make these types of calculations.

CHAPTER SIX

CONCLUSION

This study has examined the consumer valuation of fuel consumption in the Australian automobile market by utilizing data on new vehicle sales in 2014. Through a hedonic price model with a log-linear functional specification, I find that all else equal, a one-dollar per 100km decrease in the cost of travel increases the implicit recommended retail price of a vehicle by 1.69 percent. By controlling for various features that correspond to status such as fuel type, vehicle type, and various technological features I was able to obtain a more reliable estimation of the willingness to pay for fuel economy. Without such controls, the estimation of TRAVELCOST variable would have been picking up some of these characteristics, resulting in biased measurement. For example, without HYBRID the coefficient on TRAVELCOST would have been .0199 rather than .0169. Additionally, without controlling for HYRBID, SUV, SPORTS, or the technological attributes that also relate to status, the coefficient on TRAVELCOST would have been .0309. In addition to providing a more reliable estimation of TRAVELCOST, the inclusion of all of these characteristics also allowed me to disentangle a “hybrid effect”, or the effect of environmental concern found to be valued at 6.45 percent all else equal.

In the final section, the average discounted fuel cost savings from a one liter per 100 kilometer reduction in fuel consumption were found to be $2,116. Due to the functional form and variable specification, a manipulation of the data was required in order to estimate the implicit marginal willingness to pay for fuel consumption. A one liter per 100 kilometer reduction in fuel consumption was calculated to be valued at $1,427 by a marginal Australian consumer. Thus, the marginal Australian vehicle consumer, at low discount rates, seems to undervalue improvements in fuel economy.

An undervaluation of fuel cost savings could result from the fact that consumers may not be well informed in all of the benefits that a reduction in fuel consumption could bring. To address the possible lack of information, policymakers might consider an update to the labeling requirements currently in place in Australia. Since 2009, the fuel consumption label reports the fuel consumption values from the average, urban, and extra urban tests as well as the carbon emissions in grams per kilometer from the combined test (GVG). This label is part of an awareness campaign aimed at educating consumers while also enabling them to compare vehicles side by side when making a purchase decision at the dealership. More explicit statistics regarding fuel cost savings could help to address this apparent undervaluation. On the current label, the carbon emission statistic is ranked from best to worst and the label also includes the phrase “Carbon dioxide is the main contributor to climate change” (GVG). While this phrase is not overly informative, if nothing else, it reminds consumers that their fuel consumption affects climate change. Whether or not this requirement has altered consumer perception is hard to say. However, a “hybrid effect” related to environmental concern or status seeking exists in this paper’s hedonic model. Perhaps stronger language regarding fuel consumption and the potential fuel cost savings could have a similar effect in addressing the apparent undervaluation. Consumers in the Swiss vehicle market are willing to pay more for a higher fuel economy rating on the label (Alberini, Bareit, Filippini 2014). While a specific policy recommendation is beyond the scope of this study, the findings do lay the ground work for a more thorough analysis that can do just that.

Recommendations for Future Study

This study has shed some light on consumer valuation of fuel consumption in the Australian market. However, there are a few considerations or improvements that could be made in future work. While it is the belief of the author that these results are representative of the entire Australian passenger fleet, a more thorough analysis should collect the remaining passenger vehicle models. This should eliminate any possible sampling bias that could have resulted from the collection of the vehicle models.

The consumer valuation of fuel cost savings is highly dependent on the discount rate chosen. Thus, additional research should be made to discover if there is a better discount rate to utilize rather than the 1.2 percent used in this study. The marginal consumers would fully value the lifetime expected fuel cost savings if the discount rate were approximately 8.68 percent. While this rate sounds reasonable, more research would have to be done in order to better understand the Australian consumer's valuation of fuel cost savings. One could determine the average interest rate on new car loans in Australia in 2014. Such a figure would be appropriate if consumers use this rate when assessing whether a more expensive car will "payoff" with the expected fuel cost savings that they may obtain from purchasing a vehicle with lower fuel consumption.

Another prospective issue could arise regarding the weighting used in the study. The VFACTs report was monumental in detailing how many models were sold in 2014, however, it did not include any information on sub-models. In this study, a simplistic approach was used to determine the number of each sub-model sold. The total number of each model sold was divided by the number of sub-models in order to arrive at a number sold per sub-model. However, the quantity of each sub-model was undoubtedly not equal. Use of more accurate weights would help to eliminate any remaining bias in the parameter estimates.

As economic theory predicts and some studies confirm (NAP), consumers are more likely to purchase fuel efficient vehicles when gasoline prices are high and are less likely to do so when gasoline prices are low. According to the Australian Institute of Petroleum, the year 2014 happened to be the year with the highest prices at the pump from 2005 onward. Future study should attempt to collect data on the years between 2005 and 2014 for a better understanding on the valuation of fuel economy when gas prices are not as high.

Finally, other important insights could be derived from estimating the second stage in the hedonic analysis. This analysis would reveal the actual consumer demand for fuel economy. This type of analysis coupled with some of the recommendations listed above should allow for a specific recommendation for future policy changes in Australia.

REFERENCES

ABS. "Survey of Motor Vehicle Use, Australia 12 Months Ended 31 October 2014." Australian Bureau of Statistics. Australian Bureau of Statistics, 15 Oct. 2015. Web. 11 May 2016.

AIP "Annual Retail Price Data". Australian Institute of Petroleum, ORIMA Research Pty Ltd, n.d. Web. 15 Apr. 2016.

Alberini, Anna, Markus Bareit, and Massimo Filippini. "Does the Swiss Car Market Reward Fuel Efficient Cars? Evidence from Hedonic Pricing Regressions, a Regression Discontinuity Design, and Matching." SSRN Electronic Journal SSRN Journal (2014): n. pag. Web. 11 July 2016.

ANCAP. Australian New Car Assessment Program. ANCAP Safety, 2016. Web. 16 July 2016.

DIRD. "Vehicle Emissions Standards." Department of Infrastructure and Regional Development. Australian Government, 18 Mar. 2016. Web. 20 May 2016.

DRIVE. "Q&A: Torque vs. Kilowatts." Drive. N.p., 26 Sept. 2014. Web. 27 June 2016.

EC. "Reducing CO2 Emissions From Passenger Cars." Climate Action. European Commission, 27 June 2016. Web. 1 July 2016.

Edmunds. "What You Should Know Before Buying A Diesel." Diesel Buying Guide. Edmunds, n.d. Web. 24 June 2016.

Edmunds. "What You Should Know Before Buying A Hybrid." Hybrid Buying Guide. Edmunds, n.d. Web. 24 June 2016.

Espey, Molly, and Santosh Nair. "Automobile Fuel Economy: What Is It Worth?" Contemporary Economic Policy 23.3 (2005): 317-23. Web. 11 Mar. 2016.

FCAI. "Annual Report 2014". Federal Chamber of Automotive Industries. 24 Aug. 2015. Web. 12 May 2016.

FCAI. "VFACTS National Report New Vehicle Sales". Federal Chamber of Automotive Industries, Dec. 2014. 9 June 2016.

Fifer, Daniel, and Nicholas Bunn. "Assessing Consumer Valuation of Fuel Economy in Auto Markets." Duke, 2009. Web. 14 July 2016.

GFEI. "Australia Automotive Fuel Economy Policy." Global Fuel Economy Initiative. United Nations Environment Programme, 2010. Web. 10 June 2016.

Greene, David L. "How Consumers Value Fuel Economy: A Literature Review." U.S Environmental Protection Agency, Mar. 2010. Web. 15 May 2016.

GVG."Fuel Consumption Label." Green Vehicle Guide. Australian Government, n.d. Web. 5 May 2016.

Helfand, Gloria, and Ann Wolverton. "Evaluating the Consumer Response to Fuel Economy: A Review of the Literature." U.S Environmental Protection Agency, 4 May 2011. Web. 17 June 2016.

IIHS-HLDI."How Do A Vehicle's Size and Weight Affect Safety?" Vehicle Size and Weight. Insurance Institute for Highway Safety Highway Loss Data Institute, Mar. 2016. Web. 27 June 2016.

"Improving Australia's Light Vehicle Fuel Efficiency." Climate Works Australia. N.p., Feb. 2014. Web. 5 May 2016.

James, Matthew L. "Vehicle Fuel Efficiency Standards." Research Publications. Parliament of Australia, 28 June 2013. Web. 07 May 2016.

McManus, Walter. "The Link Between Gasoline Prices and Vehicle Sales." Bus Econ Business Economics 42.1 (2007): 53-60. Web. 10 June 2016.

Mellor, John. "Australia's Once-Vibrant Auto Industry Crashes in Slow Motion." New York Times. New York Times, 12 Dec. 2014. Web. 05 May 2016.

NAP. "Consumer Impacts and Acceptance Issues." Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light Duty Vehicles. N.p.: National Academic Press, 2015. 307-36. Web. 15 June 2016.

NAP. "Technologies for Reducing Fuel Consumption in Compression-Ignition Diesel Engines." Cost, Effectiveness, and Deployment of Fuel Economy Technologies for Light Duty Vehicles. N.p.: National Academic Press, 2015. 97-121. Web. 15 June 2016.

Newstead, Stuart, Linda Watson, and Max Cameron. "Vehicle Safety Ratings Estimated from Police Reported Crash Data: 2014 Update Australian and New Zealand Crashes During 1987-2012." Monash University. Monash University Accident Research Centre, Aug. 2014. Web. 19 Mar. 2016.

OECD. Inflation (CPI) (indicator). Organization for Economic Cooperation and Development, n.d. Web. 5 July 2016

OECD. Long-term interest rates (indicator). Organization for Economic Cooperation and Development, n.d. Web. 5 July 2016

Perkins, Michael, "Hedonic Analysis of the Willingness to Pay for Fuel Efficiency in the Australian Automobile Market" (2009). All Theses. Paper 666.

RACQ. “2014 Annual Fuel Price Report”. Royal Automotive Club of Queensland. N.p., n.d. Web. 2 June 2016.

Redbook. The Red Book: The Pricing Authority. Automotive Data Services Pty. Ltd. 2016 Web. 16 Apr. 2016.

Rosen, Sherwin. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." Journal of Political Economy 82.1 (1974): 34-55. Web. 11 Mar. 2016.

Sari, Mehmet, "Consumer Valuation of Fuel Economy Over Time: 2003-2012" (2014). All Theses. Paper 1844.

Turrentine, Thomas S., and Kenneth S. Kurani. "Car Buyers and Fuel Economy" Energy Policy 35.2 (2006): 1213-223. Web. 22 June 2016.

Turrentine, Tom, Kenneth Kurani, and Reid Heffner. "Fuel Economy: What Drives Consumer Choice?" (2008): n. pag. Institute of Transportation Studies. UC Davis. Web. 02 June 2016.

Youngs, Jeff. "The Advantages of Hybrid Cars." Cars Ratings and Research. J.D Power, 10 Aug. 2012. Web. 12 May 2016.

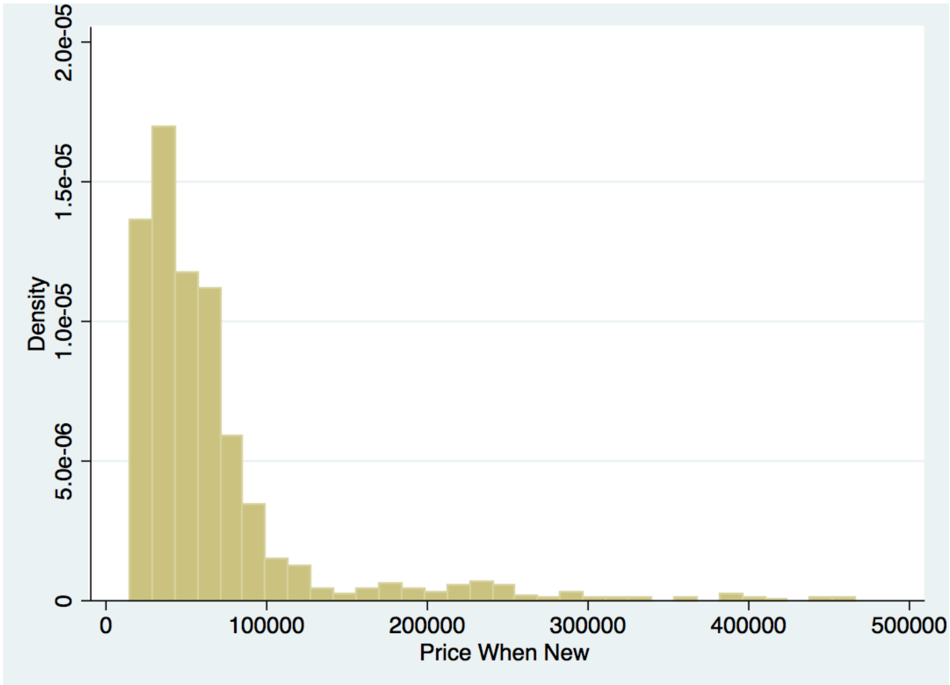

Figure 1.1: Histogram of Price

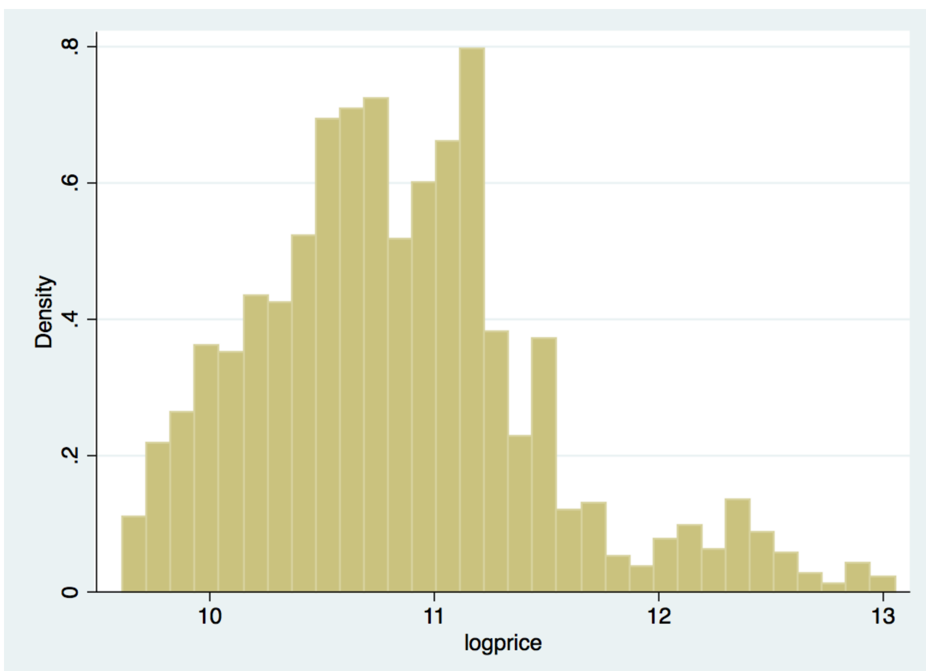

Figure 1.2: Histogram of Natural Log of Price

Table 1.1: Descriptive Statistics

VARIABLE	Mean	Sales Weighted Mean	Std. Dev.	Min	Max
PRICE ($AUD)	64215.23	38107.737	57642.94	14990	466900
QUANTITY SOLD	381.0949	N/A	459.2263	6.901961	2915.667
Performance					
PEAKPOW (kW)	155.7697	132.8145	62.90371	60	435
Size					
WHEELBASE (MM)	2754.083	2696.766	153.7851	2250	3210
KERBWEIGHT (KG)	1611.812	1519.57	328.9402	750	2829
Safety					
PRINJGACC	0.1657252	0.1857537	0.0523682	0	0.55
PRSEVGINJ	0.2239864	0.2476917	0.0937834	0	0.7142857
Other					
FUELCAPACITY (L)	64.21421	60.17564	16.5425	40	180
TRAVELCOST ($/100 KM)	11.08741	10.947752	3.026556	2.8272	22.0224
Fuel Type					
DIESEL	0.2552719	0.1934835	0.436135	0	1
PETROL	0.7352941	0.7961801	0.4412989	0	1
LPG	0.009434	0.0103363	0.0966962	0	1
Vehicle Type					
HYBRID	0.0238624	0.0192018	0.1526627	0	1
SUV	0.2924528	0.3546096	0.4550155	0	1
SPORTS	0.0416204	0.0466726	0.1997756	0	1
Technology					
NAVIGATION	0.5926748	0.4262217	0.4914727	0	1
CAMERA	0.5377358	0.4289568	0.4987124	0	1
BLINDSPOT	0.1204218	0.1041488	0.3255444	0	1
COLLISION	0.1603774	0.058821	0.3670575	0	1
LANEDEPART	0.1509434	0.0479282	0.3580931	0	1

Table 1.2 (Cont.): Descriptive Statistics

VARIABLE	Mean	Sales-Weighted Mean	Std. Dev.	Min	Max
Make					
AUDI	0.0593785	0.0226405	0.2363973	0	1
BMW	0.2142064	0.0285045	0.4103846	0	1
FORD	0.0432852	0.0455679	0.203555	0	1
HOLDEN	0.0577137	0.0820858	0.2332659	0	1
HONDA	0.0355161	0.0439516	0.1851316	0	1
HYUNDAI	0.0665927	0.1351617	0.2493844	0	1
JEEP	0.0399556	0.0341894	0.1959093	0	1
KIA	0.0255272	0.026929	0.1577636	0	1
LAND ROVER	0.0371809	0.0054417	0.1892574	0	1
MAZDA	0.0566038	0.1227682	0.2311481	0	1
MERCEDES	0.0776915	0.0335036	0.2677597	0	1
MITSUBISHI	0.0305216	0.0543312	0.1720654	0	1
NISSAN	0.0310766	0.0448966	0.1735729	0	1
RENAULT	0.0072142	0.0038021	0.084653	0	1
SSANGYONG	0.0038846	0.0006713	0.0622224	0	1
SUBARU	0.0371809	0.0514654	0.1892574	0	1
SUZUKI	0.0155383	0.0176255	0.1237148	0	1
TOYOTA	0.0610433	0.1860228	0.2394762	0	1
VOLKSWAGEN	0.0410655	0.046063	0.1984968	0	1
VOLVO	0.0166482	0.0035167	0.1279848	0	1
PEUGEOT	0.0066593	0.0012479	0.0813547	0	1
LEXUS	0.0122087	0.004351	0.1098467	0	1
CHRYSLER	0.0055494	0.0023007	0.0743079	0	1
PORSCHE	0.0099889	0.000533	0.0994717	0	1
MINI	0.0077691	0.0024289	0.0878241	0	1

Table 2.1: Results of Sales-Weighted Estimation of a Model of the Natural Logarithm of a Vehicle's Recommended Sales Price as a Function of Vehicle Characteristics

VARIABLE	Estimated Coefficient	Robust Standard Error	T Statistic	Prob > |t|
Performance				
PEAKPOWER	0.0034157	0.0001622	21.06	0
Size				
WHEELBASE	-0.0000172	0.0000603	-0.28	0.776
KERBWEIGHT	0.0006217	0.0000401	15.51	0
Safety				
PRINJGACC	-0.1358388	0.0791372	-1.72	0.086
PRSEVGINJ	-0.1110548	0.0432001	-2.57	0.01
Other				
FUELCAPACITY	0.0018084	0.0003963	4.56	0
TRAVELCOST	-0.0169094	0.0028489	-5.94	0
Fuel Type				
DIESEL	0.0624487	0.0116	5.38	0
Vehicle Style or Type				
HYBRID	0.0624986	0.0233698	2.67	0.008
SUV	0.0472555	0.0125357	3.77	0
SPORTS	0.0085628	0.0208104	0.41	0.681
Technology				
NAVIGATION	0.1311231	0.0089149	14.71	0
CAMERA	0.0628961	0.0097207	6.47	0
BLINDSPOT	0.0713254	0.0130479	5.47	0
COLLISION	0.0400059	0.0148897	2.69	0.007
LANEDEPART	0.0665089	0.0165866	4.01	0

F(40, 1761) =	1275.46
Prob > F =	0
R-squared =	0.9471

Table 2.2: (Cont.): Results of Sales-Weighted Estimation of a Model of the Natural Logarithm of a Vehicle's Recommended Sales Price as a Function of Vehicle Characteristics

VARIABLE	Estimated Coefficient	Robust Standard Error	T Statistic	Prob > |t|
Make Fixed Effects				
AUDI	0.4045582	0.0209047	19.35	0
BMW	0.4593117	0.021752	21.12	0
FORD	-0.050508	0.01799	-2.81	0.005
HOLDEN	-0.1312416	0.0171174	-7.67	0
HONDA	0.0543278	0.02186	2.49	0.013
HYUNDAI	-0.0141613	0.0166431	-0.85	0.395
JEEP	-0.1510888	0.0222963	-6.78	0
KIA	-0.0335229	0.0216556	-1.55	0.122
LANDROVER	0.1978158	0.037367	5.29	0
MAZDA	-0.0362526	0.0175588	-2.06	0.039
MERCEDES	0.3829698	0.0210852	18.16	0
MITSUBISHI	0.0473654	0.0211655	2.24	0.025
NISSAN	0.0342563	0.018486	1.85	0.064
RENAULT	0.0760966	0.0342374	2.22	0.026
SSANGYONG	-0.0472064	0.1050299	-0.45	0.653
SUBARU	0.0559662	0.0159214	3.52	0
SUZUKI	0.0180064	0.0341264	0.53	0.598
VOLKSWAGEN	0.1605457	0.019965	8.04	0
VOLVO	0.2408156	0.0238765	10.09	0
PEUGEOT	0.1231257	0.0314717	3.91	0
LEXUS	0.3846928	0.0399627	9.63	0
CHRYSLER	-0.2017904	0.0365977	-5.51	0
PORSCHE	1.663202	0.0409149	40.65	0
MINI	0.6152687	0.0193066	31.87	0
_CONS	9.0564	0.1340551	67.56	0