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What Are Hybrid Vehicle Buyers Really Paying For? An Empirical Analysis

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WHAT ARE HYBRID VEHICLE BUYERS REALLY PAYING FOR?
AN EMPIRICAL ANALYSIS

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ABSTRACT

The increasing popularity of eco-labeled products has given rise to numerous studies showing that consumers will pay more for eco-labeled products than for similar non-labeled products. One such pairing is hybrid vehicles and traditional combustion engine vehicles. This analysis is the first attempt at identifying a willingness to pay for the hybrid vehicle label in excess of the willingness to pay for fuel economy and reduced vehicle emissions. In this analysis I apply a hedonic price model to new vehicle data from 2012, and also analyze county-level vehicle registration data from Oregon. The hedonic price analysis shows that, for given levels of fuel consumption and vehicle emissions, consumers pay more for a vehicle bearing the hybrid label. The Oregon analysis shows that areas with higher proportions of environmentalists have higher proportions of hybrid cars, even in locations that are not suited to hybrid use. Together, these results suggest that consumers will pay more for a vehicle that bears the hybrid label because that label increases the owner's social status in the environmental community and conveys to others the strength of the owner's environmental commitment.

DEDICATION

This thesis is dedicated to my parents Ralph and Roberta Partridge, my brother Jared Partridge, and my fiancé Clay Bohn for their unconditional love, support, and guidance.

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CHAPTER ONE

INTRODUCTION

Green products have become increasingly popular over recent years. For example, the Organic Trade Association (2011a) reports that the organic industry in the United States grew by 7.7% to $28.6 billion in 2010, and that 78% of families in the United States purchased organic foods in 2011 (Organic Trade Association, 2011b). In order for consumers to purchase green products, they must first be able to identify green products. Information regarding a product's environmental attributes can be communicated to consumers by eco-labels. In this way, eco-labels are designed to reduce information asymmetry between consumers and producers (Delmas & Grant, 2010). Eco-labeling has become so prevalent that the Ecolabel Index currently tracks 435 eco-labels in 197 countries across 25 industry sectors (Ecolabel Index, 2013). Eco-labels are only capable of reducing information asymmetry if labels clearly and accurately represent their products. Delmas and Grant (2010) highlight several instances where the presence of an eco-label actually causes consumers to perceive a product as less environmentally friendly, either because the label is confusing or because consumers believe the label is intentionally misrepresentative of the product.

Communication between consumers and producers can also be hindered if consumers attach significance to eco-labels beyond the environmental qualities the labels were intended to represent. This effect can be seen with hybrid vehicles. A vehicle with a hybrid engine uses less fuel and emits less pollution than a vehicle with a traditional combustion engine driven the same distance (Sims Gallagher & Muehlegger, 2011). However, these attributes are not the only messages consumers infer from the hybrid label. Consumers who self-identify as environmentalists also derive benefit from being seen in hybrid cars, as these vehicles communicate to others the strength of the owners' environmental commitment (Kahn, 2007). Halbright and Dunn (2010) argue that this is why the Toyota Prius was the first hybrid car to succeed in the U.S. market. The Prius was first introduced into the U.S. market in 2001 and only sold 15,000 units that year. It also looked very much like any other small car. Sales did not take off until the second generation Prius was introduced in 2004, featuring a visually distinctive body design. Prius owners reported that they chose the Prius because it makes a clear and strong statement about them, and that other hybrid cars were too subtle (Maynard, 2007). Other car manufacturers have developed similar but distinct identities for their hybrid models. In a New York Times article describing the Honda Accord Hybrid, John M. Broder (2004) characterizes Honda's perception of its hybrid customers as "a conservative bunch, not the sort to advertise their virtue like owners of the Toyota Prius, who may want everyone to think their cars can run on egg whites and organic chardonnay" (para. 5).

The hybrid label, therefore, confers social status on a vehicle's owner (Kahn, 2007). If consumers value this social status, then one would expect the price premium commanded by a hybrid vehicle over a traditional vehicle to be in excess of what can be explained by decreased fuel consumption and cleaner emissions alone. I apply a hedonic price analysis to data on new vehicles available in the United States and Canada in 2012 to determine if consumers will pay more for a hybrid vehicle than a traditional vehicle after controlling for fuel consumption and emissions. I also examine county-level vehicle registration data from Oregon to assess the relationship between hybrid ownership and environmentalism. Chapter Two contains a review of previous research. In Chapter Three, I discuss the hedonic price model, data set, and variables. Chapter Four contains the results of the hedonic price analysis and a discussion of the results. Chapter Five contains a description and analysis of the Oregon data set. Chapter Six contains a summary and conclusions.

CHAPTER TWO

PREVIOUS LITERATURE

There is a long history of using the hedonic method to evaluate automobile pricing and attributes (Atkinson & Halvorsen, 1984; Ohta & Griliches, 1986; Dreyfus & Viscusi, 1995; as in Kiso, 2010). According to Lancaster (1966) and Griliches (1971), the price of a car represents the valuation of the attributes of the car (as in Couton, Gardes, & Thepaut, 1996). Initially, hedonic studies of automobiles were employed to estimate quality-adjusted prices (Court, 1939; Triplett, 1969, 1986; Cowling & Cubbin, 1971; Griliches, 1971; Ohta & Griliches, 1976; as in Espey & Nair, 2005). Later research focused on the valuation of safety features and used these estimates to derive values of life (Atkinson & Halvorsen, 1984; Dreyfus & Viscusi, 1995; Dunham, 1997; as in Espey & Nair, 2005). Hedonic evaluations have also been done of the relationship between vehicle quality and warranties (Douglas, Glennon, & Lane, 1993; as in Espey & Nair, 2005) and of producer market power (Mertens & Ginsburgh, 1985; Thompson, 1987; as in Espey & Nair, 2005). There have been many studies attempting to estimate consumer willingness to pay for fuel economy (Atkinson & Halvorsen, 1984; Couton, Gardes, & Thepaut, 1996; Espey & Nair, 2005; Goodman, 1983; Kiso, 2010). As far as I am aware, no one has previously attempted to identify a willingness to pay for the hybrid label in excess of the willingness to pay for fuel economy and reduced emissions.

It has been well established that consumers are willing to pay more for eco-labeled products than for comparable non-labeled products (Asche, Larsen, Smith, Sogn-Grundvag, & Young, 2013; Blend & van Ravenswaay, 1999; Nimon & Beghin, 1999). Nimon and Beghin (1999) found that consumers are willing to pay 33% more for clothing made with organic cotton than for clothing made with non-organic cotton. In some cases, the presence of an eco-label commands a price premium while variations in the strength of the label do not. Blend and van Ravenswaay (1999) found that consumers were willing to pay more for eco-labeled apples than for non-labeled apples, but that a government-backed label with stringent environmental restrictions commanded the same premium as an unverified label with few environmental restrictions. Delmas and Grant (2010) found a significant price premium for eco-certified wine that lacked an eco-label but no premium for eco-certified, eco-labeled wine. They argue that the certification process requires changes to the wine-making operation which result in an improved product, but that eco-labels for wine are new and poorly understood by consumers and thus tend to be ignored. Studies that specifically address hybrid vehicles tend to focus on the relationship between hybrid adoption and government incentives (Beresteanu & Li, 2011; Sims Gallagher & Muehlegger, 2011) or the relationship between consumer choice and social identity (Kahn, 2007; Owen, Videras, & Wu, 2010).

CHAPTER THREE

METHODOLOGY

Model

This analysis follows the hedonic price methodology established by Rosen (1974; as in Espey & Nair, 2005). Automobiles are valued because they provide travel services. The attributes of a vehicle, such as size, comfort, and engine power, determine the utility a consumer derives from the travel services provided by the vehicle. The price of an automobile reflects the valuation of these attributes, which vary across automobile models (Couton, Gardes, & Thepaut, 1996). Thus, the price of a vehicle, represented by the hedonic price function, is as follows:

$$P_{vehicle} = P\ (A_1, A_2, \ldots , A_k, \ldots , A_n) \tag{1}$$

where each A_i is an attribute and the vehicle is comprised of *n* attributes. The implicit marginal price of an attribute is found by taking the partial derivative of this function with respect to that attribute. Therefore, the marginal price of attribute A_k would be as follows:

$$p\ (A_k) = \partial P_{vehicle}\ /\ \partial A_k. \tag{2}$$

In equilibrium, this represents the maximum amount that a consumer is willing to pay for an additional unit of attribute A_k and the minimum amount that a producer would be willing to accept to produce another unit of attribute A_k.

Data and Variables

Most of the data for this analysis were provided by The Vehicle List (2013), an online vehicle database that caters to web developers. The database was initially compiled by a third party data company and is validated against industry standards such as Kelley Blue Book and is updated quarterly. The data consist of 2,323 observations of new cars, SUVs, trucks, minivans, and vans available in the United States and Canada in 2012, and include the Manufacturer's Suggested Retail Price (MSRP) and vehicle specifications. Emissions data were taken from The Fuel Economy Guide, Model Year 2012 produced by the U.S. Environmental Protection Agency and the U.S. Department of Energy (2013). Fuel economy and emissions data were not available for all observations and those vehicles missing these data were eliminated from the dataset. The reduced dataset contains 1,909 observations.

Vehicle attributes were chosen in accordance with previous hedonic price analyses of automobiles (Atkinson & Halvorsen, 1984; Couton, Gardes, & Thepaut, 1996; Espey & Nair, 2005; Goodman, 1983; Kiso, 2010)[1]. Variables representing price, size, power, performance, comfort, and luxury status are included to control for non-environmental attributes which affect a vehicle's desirability. Variables for fuel consumption and emissions rating represent the environmental attributes conveyed by the hybrid label. A variable indicating whether or not a vehicle bears the hybrid label is also included. Summary statistics are reported in Table 1.

The price of a vehicle is represented by the Manufacturer's Suggested Retail Price (MSRP). MSRP is the price set by the manufacturer and includes destination charges and minimum required equipment (Kelley Blue Book, 2013). MSRP is the same for all vehicles of a given make, model, and options package regardless of location. The actual sales price of a vehicle may not be the same as MSRP. While actual sales prices are the preferable measure

[1] Two variables of relevance that are not included in this analysis are government incentives and safety. It is likely that government incentives, such as tax credits, affect how much a consumer is willing to pay for a vehicle. Because of the complexity of state and federal government incentives, including them is outside the scope of this analysis. A variable representing vehicle safety was originally intended to be included in this analysis. However, comprehensive safety data were not available. Therefore the safety variable had to be excluded from this analysis.

Table 1. Summary Statistics of 2012 Vehicle Data.

Variable	Mean	Standard Deviation	Minimum	Maximum
Price (US$)	42,623.14	44,053.26	10,990	470,350
Curb weight (lb)	3,932.865	945.6004	1,808	6,641
Engine size (L)	3.382085	1.353679	1	7
Turning diameter (ft)	38.42965	4.008204	25.8	54.5
Leather	.4300681	.4952151	0	1
Luxury	.2205343	.4147156	0	1
Fuel consumption (gal/100mi)	4.838795	1.216478	1.052632	8.333333
Air Pollution	5.2923	.747251	2	8
Hybrid	.0408591	.1980156	0	1

Note: N = 1909.

they are difficult to obtain and MSRP is typically used instead (Beresteanu & Li, 2011). The average MSRP for the vehicles in this dataset is $42,623. The Nissan Versa sedan with a manual transmission is the least expensive vehicle in the dataset with an MSRP of $10,990. The Maybach 62 S sedan is the most expensive vehicle in the dataset with an MSRP of $470,350[2].

Vehicle size is represented by the curb weight of the vehicle. Vehicle length, width, and wheelbase are also indicators of vehicle size. Espey and Nair (2005) argue that curb weight is the best indicator of size because length and width are one-dimensional, wheelbase varies with vehicle design, and curb weight is most highly correlated with the other size indicators. The average curb weight of the vehicles in this dataset is 3,933 pounds. The smallest vehicles in the dataset are the Smart Fortwo Pure Coupe and the Smart Fortwo Passion Coupe, each with a curb weight of 1,808 pounds. The largest vehicles in the dataset are the Ford E-350 XL Extended Wagon and the Ford E-350 XLT Extended Wagon, each with a curb weight of 6,641 pounds.

[2] It is reasonable to expect that a functional form may not hold for observations at the top end of MSRP range. To account for this, I excluded all observations with MSRP more than 3 standard deviations from the mean (48 observations) and repeated the analysis. Results were similar to those reported for the full dataset.

Vehicle power is represented by engine size measured as engine displacement. Engine displacement refers to the volume of space in the engine cylinders. Higher displacement means there is more room for fuel to be burned, and hence a more powerful engine (O'Reilly Auto Parts, 2013). The average engine displacement of vehicles in this dataset is 3.38 liters. The vehicles with the lowest engine displacements in the dataset are the Smart Fortwo family of vehicles, with engine displacements of 1 liter. The vehicle with the highest engine displacement in the dataset is a Chevrolet Corvette with an engine displacement of 7 liters.

Vehicle performance is represented by turning diameter. Turning diameter measures the clearance needed for the vehicle to complete a U-turn (Espey & Nair, 2005). Holding all other vehicle specifications constant, a smaller turning diameter implies better handling. The average turning diameter of the vehicles in this dataset is 38.4 feet. The vehicle with the smallest turning diameter in this dataset is the Scion iQ with a turning diameter of 25.8 feet. The vehicles with the largest turning diameters in this dataset are the Chevrolet Express and Express Cargo vans and the GMC Savana and Savana Cargo vans, each with a turning diameter of 54.5 feet.

Vehicle comfort is represented by a dummy variable which is equal to 1 if a vehicle has leather seats and is equal to 0 if a vehicle does not have leather seats. Leather seats are generally indicative of vehicle characteristics which provide a more comfortable vehicle interior (Baltas & Saridakis, 2010). 43% of the vehicles in this dataset have leather seats.

Espey and Nair (2005) argue that the majority of vehicle categories, such as small, large, coupe, and wagon, will be captured by size, power, and performance variables. The only category which will not be captured by other variables is luxury vehicles. Therefore, a dummy variable for luxury is included and is equal to 1 if a vehicle is considered a luxury vehicle and is equal to 0 if a vehicle is not considered a luxury vehicle. 22.1% of the vehicles in this dataset are considered luxury vehicles.

Vehicle specifications in the United States generally report vehicle fuel economy, measured in miles per gallon. Previous research has found that vehicle fuel consumption, measured in gallons per 100 miles, better represents the fuel costs consumers can expect over the lifetime of a vehicle (Espey & Nair, 2005; Kiso, 2010). Since lifetime fuel cost affects the lifetime cost of the vehicle, fuel consumption is more appropriate to consider when making a vehicle purchasing decision than is fuel economy. Fuel economy is represented by the Environmental Protection Agency combined estimate, which gives the fuel economy one can expect if 55% of driving takes place in stop-and-go traffic and 45% of driving takes place on rural roads or highways (U.S. Environmental Protection Agency & the U.S. Department of Energy, 2013). Therefore, the combined fuel economy estimate is a better representation of a vehicle's overall fuel economy than is either the city fuel economy estimate or the highway fuel economy estimate alone. The combined fuel economy estimate captures the fact that hybrid vehicles can achieve high fuel economy under stop-and-go driving conditions, but not under highway driving conditions. Fuel consumption is calculated by taking the inverse of fuel economy and multiplying by 100 to give gallons per 100 miles driven. The average fuel consumption of vehicles in this dataset is 4.8 gallons per 100 miles. The Toyota Prius Plug-in Hybrid has the lowest fuel consumption of vehicles in this dataset, using 1.05 gallons per 100 miles driven. The highest fuel consumption of vehicles in this dataset is 8.33 gallons per 100 miles driven. Several vehicles in this dataset report this fuel consumption, including the Chevrolet Suburban SUV, the Chevrolet Express van, the GMC Yukon XL SUV, the Lexus LFA coupe, the Maybach 57 and 57 S sedans, and the Maybach 62 and 62 S sedans.

Vehicle emissions are represented by a vehicle's federal Air Pollution Score. This score measures a vehicle's tailpipe emissions and compares them to U.S. government standards (U. S. Environmental Protection Agency [EPA], 2013). The score is on a scale from 1 to 10, where a score of 10 indicates that a vehicle emits no pollutants that contribute to local and regional air pollution. The federal government also measures greenhouse gases and rates vehicles on the Greenhouse Gas Scale. This score is directly related to a vehicle's fuel economy. That is, vehicles with higher fuel economy will have higher Greenhouse Gas Scores (EPA, 2013). Therefore, this metric should be captured by fuel consumption and is not included in this analysis. The average Air Pollution Score for vehicles in this dataset is 5.3. The lowest Air Pollution Score for vehicles in this dataset is 2. 33 vehicles in this dataset had Air Pollution Scores of 2. The highest Air Pollution Score for vehicles in this dataset is 8. 5 vehicles in this dataset reported this Air Pollution Score, including the Honda Civic Hybrid, the Honda Civic Natural Gas, the Honda CR-Z, the Hyundai Sonata Hybrid, and the Kia Optima Hybrid.

Whether or not a vehicle is labeled as a hybrid vehicle is represented by a dummy variable which is equal to 1 if the vehicle bears the hybrid label and is equal to 0 if the vehicle does not bear the hybrid label. 4% of the vehicles in this dataset are labeled as hybrid vehicles.

The variables detailed above comprise the base model of this analysis. It is clearly not possible to include variables which account for all attributes consumers value. It is therefore likely that the estimated effects of these variables will include the effects of other attributes not accounted for in the base model. One attribute which can affect a consumer's perception of vehicle quality and reliability is the vehicle's country of origin (Couton, Gardes, & Thepaut, 1996). Here country of origin refers to the country in which the vehicle maker is based, not the country where the vehicle was actually built. Country of origin dummy variables will be added to the base model in order to observe the effect on the estimates of base model variables. The vehicles in this dataset originated in 7 countries, including England, Germany, Italy, Japan, South Korea, Sweden, and the United States. The distribution of vehicles by country of origin is given in Table 2.

Table 2. Vehicle Distribution by Country of Origin.

Country of Origin	Number of Vehicles	Percentage of Total Vehicles
England	80	4.19
Germany	417	21.84
Italy	18	0.94
Japan	639	33.47
South Korea	118	6.18
Sweden	33	1.73
United States	604	31.64
Total	1,909	99.99

Note: Percentage of total vehicles does not sum to 100% because of rounding.

All vehicles originating in the same country do not have the same attributes. It is likely that even when countries of origin are added to the base model the estimated effects of the base model variables will still contain effects of unspecified attributes. To further control for variation between vehicle manufacturers, dummy variables for each manufacturer will be added to the base model in order to observe the effect on the estimates of base model variables. There are 42 makers represented in the dataset. The maker with the most models represented in the dataset is Volkswagen with 221 models, comprising 11.58% of the observations. The maker with the fewest models represented in the dataset is Bentley with 2 models, comprising 0.10% of the observations. The complete distribution of vehicles by maker is given in Appendix A.

CHAPTER FOUR

EMPIRICAL RESULTS AND DISCUSSION

The hedonic price model was estimated by linear regression using ordinary least squares. Robust standard errors were used because it is unlikely that this dataset satisfies the homoskedasticity assumption. Three versions of the hedonic price model were estimated. The first version contains only the base model variables: price, curb weight, engine size, turning diameter, leather, luxury, fuel consumption, air pollution, and hybrid. The second version adds country of origin indicators to the base model variables. The third version adds maker indicators to the base model variables. The regression results for the base model variables for each version are reported in Table 3. The full regression results for the versions containing country of origin indicators and maker indicators are reported in Appendix B.

The estimated effects of these vehicle attributes should not be taken as literal estimates of the dollar values of the attributes. For example, consumers are not willing to pay $8,331 or more to add leather seats to a vehicle. The directions of the estimated effects are of more interest than the magnitudes of the estimated effects. The magnitudes of the estimated effects are of interest when comparing the base model, the model including country of origin, and the model including makers to each other.

Curb weight represents vehicle size and I would expect consumers to be willing to pay more for a larger vehicle. It is therefore somewhat surprising that the estimated effect of curb weight is negative in all three regressions. The negative effect makes sense, however, when curb weight is interpreted conditional upon engine size. Given two vehicles with engines of the same size, a smaller vehicle is likely to be sportier and therefore more expensive. For example,

Table 3. Regression Results for Price on Base Model, Base Model with Country of Origin, and Base Model with Maker.

Price	<u>Base Model</u> **Estimate** **(Std. Error)**	<u>Base Model w/ Country</u> **Estimate** **(Std. Error)**	<u>Base Model w/ Maker</u> **Estimate** **(Std. Error)**
Curb weight	-22.9304***	-9.11918**	-7.086072**
	(3.66829)	(3.595859)	(3.144758)
Engine size	11,756.51***	9,292.461***	7,563.483***
	(2,177.123)	(1,671.437)	(973.0125)
Turning diameter	-939.209***	-446.363*	-543.7902***
	(300.5339)	(273.1122)	(149.4134)
Leather	16,964.42 ***	15,270.64***	8,331.136***
	(1,796.864)	(1,472.897)	(738.9328)
Luxury	12,816.51***	3,419.611	5,109.212
	(2,731.438)	(3,409.668)	(4,570.404)
Fuel consumption	21,273.63***	13,901.47***	8,583.9***
	(3,843.608)	(3,718.053)	(2,930.248)
Air pollution	2,309.44***	2,958.368***	1,508.646***
	(870.4958)	(843.0743)	(379.7089)
Hybrid	31,037.01***	26,709.02***	16,698.26***
	(5,155.711)	(4,936.517)	(3,299.043)
Constant	2,585.816	-41,146.4**	4,073.944
	(12,576.23)	(16,197.62)	(8,624.46)
Observations	1909	1909	1909
R^2	0.4215	0.5792	0.8540

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

the Porsche 911 Carrera and the Hyundai Genesis Coupe both have 3.8 liter engines. The Porsche weighs 3,131 pounds and costs $91,900, while the Hyundai weighs 3,397 pounds and costs $32,250. While there are many other differences between these two vehicles, the 3.8 liter engine feels more powerful in the lighter Porsche than in the heavier Hyundai. Consumers are therefore willing to pay more for the smaller vehicle.

The estimated effect of engine size is positive, as would be expected. Given two vehicles of the same size, the vehicle with the more powerful engine is likely to be sportier and more expensive. Likewise, the negative estimated effect for turning diameter makes sense.

Given two vehicles of the same curb weight and engine size, the vehicle with the smaller turning diameter should handle better and be more expensive. Allowing curb weight and engine size to vary could yield a different result. The Ford Mustang has a larger turning diameter than the Toyota Yaris. The Mustang also weighs more than the Yaris and has a larger engine. However, the Mustang is the more performance-oriented vehicle and the prices reflect this ($33,710 for the Mustang and $15,625 for the Yaris).

The positive estimated effect for leather seats is to be expected. Leather seats represent a host of vehicle attributes that make traveling in a vehicle more comfortable. Consumers value comfort and are willing to pay a higher price for a more comfortable vehicle. Similarly, the positive estimated effect for luxury vehicles is to be expected. It is interesting to note that the luxury dummy variable is statistically significant in the base model but not in the models including country of origin and maker. Luxury is a subjective attribute; what is luxurious to one consumer may not be luxurious to another. Luxury status loses it explanatory power when country of origin and maker are included because those attributes are objective and allow consumers to decide for themselves whether or not a vehicle is luxurious.

The positive estimated effect of fuel consumption is initially surprising. This implies that, all else equal, consumers will pay more for a vehicle that requires more fuel to travel a given distance. A vehicle with greater fuel consumption will require more fuel over its lifetime and will therefore have a higher lifetime fuel cost. However, as with vehicle size, fuel consumption should be considered in conjunction with other attributes. As illustrated in Table 4, fuel consumption is highly correlated with both curb weight and engine size. Consumers are willing to pay more for roomier, more powerful vehicles and those vehicles tend to have higher fuel consumption.

Table 4. Correlation Matrix for Fuel Consumption, Curb Weight, and Engine Size.

	Fuel Consumption	Curb Weight	Engine Size
Fuel Consumption	1.0000	-	-
Curb Weight	0.7968	1.0000	-
Engine Size	0.8755	0.8109	1.0000

The positive estimated effect for Air Pollution Score makes sense. A higher score is indicative of cleaner tailpipe emissions. Consumers who are concerned with how their vehicles impact the environment will be willing to pay more for a vehicle that emits fewer pollutants. Consumers who are not concerned with their vehicles' environmental impact may also be willing to pay more for a vehicle that emits fewer pollutants if cleaner emissions are indicative of other desirable vehicle attributes such as a more efficient engine.

The estimated effect of bearing the hybrid label is positive and statistically significant in all three regressions. This indicates that, for given levels of fuel consumption and emissions, consumers pay more for a vehicle that bears the hybrid label. Since the hybrid label is intended to identify vehicles that consume less fuel and have cleaner emissions, this result implies that consumers are receiving value from the hybrid label itself and not just the attributes it represents. Previous research suggests that this value is elevated social status derived from being seen in a hybrid vehicle (Sims Gallagher & Muehlegger, 2011; Kahn, 2007).

Comparing the base model to the models with countries of origin and makers, most estimated effects decrease in magnitude as the model becomes more finely specified. That is, including country of origin decreases the estimated effects of the base model attributes because country of origin captures some of the quality and reliability effects that were previously ascribed to the base model attributes. Likewise, including vehicle maker captures some of the variation in quality and reliability between makers who are from the same country. Not all estimates are strictly decreasing from base model to country of origin model to maker model, but estimated effects in the country of origin and maker models are both generally of smaller magnitude than those in the base model. The effects of unspecified vehicle attributes are clearly still being captured by the estimated effects of the base model attributes even in the model which includes maker dummy variables. This can be seen in the estimated effect of bearing the hybrid label. The hybrid effect decreases from $31,037 in the base model to $16,698 in the maker model. However, this is still an unreasonably high estimate.

CHAPTER FIVE

OREGON ANALYSIS

One drawback of the preceding hedonic price analysis is that it does not represent the demand for hybrid vehicles. Even assuming that the MSRP is a perfect reflection of the actual sales price of a vehicle, the hedonic price analysis contains no information on the quantity of vehicles sold. I will address this issue using county-level data from Oregon. Hybrid vehicles are best suited for urban areas. Therefore, hybrid registration rates should be increasing with population density. If consumers are buying hybrids in order to elevate their social status, hybrid registration rates should be increasing with environmentalism (Kahn, 2007).

Much of the data for this analysis were taken from the Data Center of the Statesman Journal (Statesman Journal Data Center, 2012a, 2012b), a newspaper in Salem, Oregon. The Statesman Journal Data Center is an interactive presentation of data compiled from a variety of Oregon state entities. Data on population, income, and vehicle registration originated with the Driver and Motor Vehicle Services Division (DMV) of the Oregon Department of Transportation. Voter registration data originated with the Office of the Oregon Secretary of State. Data on county size and city populations were taken from the Oregon Blue Book (2013), the state's official directory and fact book. Data on education were taken from the U. S. Census Bureau (2013). All data are from 2011 except for Census data which is from 2010. Summary statistics are reported in Table 5.

There are 36 counties in the state of Oregon. The average county population in Oregon is 106,419 people. Multnomah County has the largest population with 735,334 people and Wheeler County the smallest population with 1,441 people. The average county in Oregon

Table 5. Summary Statistics of Oregon County Data.

Variable	Mean	Standard Deviation	Minimum	Maximum
Population	106,418.7	162,542.1	1,441	735,334
Area (sq mi)	2,698.056	2,502.897	465	10,228
Population density (pop/sq mi)	106.7102	283.3663	.7256551	1,581.363
Median income (US$)	44,295.47	6,723.466	33,403	62,574
College degree	.2166944	.078135	.107	.474
Hybrid/elec. per 1,000 gas	14.48222	4.769464	8.27	29.39
Pacific Green share	.0026887	.0017763	0	.0076061

Note: N = 36.

covers 2,698 square miles. The largest county in Oregon is Harney County with 10,228 square miles and the smallest county is Multnomah County with 465 square miles. Population density is calculated by dividing population by area. The average county population density in Oregon is 106.7 people per square mile. Multnomah County has the highest population density in Oregon with 1,581 people per square mile. Harney County has the lowest population density in Oregon with less than 1 person per square mile.

The average median county income in Oregon is $44,295. Washington County has the highest median county income in Oregon at $62,574 and Wheeler County has the lowest median county income at $33,403. In the average Oregon county, 22% of people age 25 or older have a college degree. Benton County has the highest proportion of residents with a college degree, at 47%. Morrow County has the lowest proportion of residents with a college degree, at 11%. Counties with more educated residents and higher average incomes are expected to have more hybrid cars (Sims Gallagher & Muehlegger, 2011; Kahn, 2007).

The Oregon DMV reports the number of registered hybrid and electric vehicles per 1,000 registered gas vehicles for each county. The average county in Oregon has 14.5 hybrid and electric vehicles per 1,000 gas vehicles. Benton County has the highest proportion of hybrid and electric vehicles, with 29.4 hybrid and electric vehicles per 1,000 gas vehicles. Grant County has the lowest proportion of hybrid and electric vehicles, with 8.3 hybrid and electric vehicles per 1,000 gas vehicles.

The intensity of environmentalism in a county is measured by the proportion of registered voters who are members of the Pacific Green Party. The Pacific Green Party states that its mission is to promote the values of "Peace, Sustainability, Social and Economic Justice, and Grassroots Democracy" (Pacific Green Party, 2012, para. 1). Kahn (2007) shows that the proportion of green party membership in a community is a good proxy for the intensity of environmental sentiment in the community. The proportion of registered voters who belong to the Pacific Green Party in the average Oregon county is 0.2%. Multnomah County has the highest proportion of registered voters who belong to the Pacific Green Party at 0.7% and Wheeler County has the lowest proportion with no Pacific Green Party members at all. The small proportion of registered voters who belong to the Pacific Green Party suggests that the party has little political strength and that party membership is an expression of ideology (Kahn, 2007).

Three linear regressions using ordinary least squares are estimated for this data. The first regression predicts proportion of hybrid and electric vehicles from income, population density, college education, and the Pacific Green Party's share of registered voters. The second regression adds a dummy variable indicating whether or not a county contains a city with a population of 50,000 or greater. This accounts for the fact that higher county population density does not necessarily indicate the presence of an urban environment suitable for a hybrid car. There are 10 such counties in Oregon. The third regression takes this idea further, adding dummy variables for the three largest cities in Oregon. These cities are Portland (population

585,845), Eugene (157,010), and Salem (155,710). Portland spans the counties of Clackamas, Multnomah, and Washington. Eugene is located in Lane County, and Salem spans the counties of Marion and Polk. The results of these regressions are reported in Table 6.

Table 6. Regression Results for Hybrid/Electric on Base Variables, Base Variables with Big City Indicator, and Base Variables with Portland, Eugene, and Salem Indicators.

Hybrid/electric proportion	**Base Model** Estimate (Std. Error)	**Base Model w/ Big City** Estimate (Std. Error)	**Base Model w/ Portland, Eugene, Salem** Estimate (Std. Error)
Income	0.0000095	0.00000517	-0.0000153
	(.0000691)	(.0000741)	(0.000087)
Population density	0.0018218	0.0017931	0.0006973
	(.0011337)	(0.0010901)	(0.0016123)
College degree	34.81158***	34.25143***	32.77337***
	(7.807286)	(7.838103)	(9.140902)
Pacific Green share	824.8555***	817.8458**	927.4813***
	(286.1213)	(307.6924)	(335.4423)
Big City	-	0.2367229	-
		(1.123063)	
Portland	-	-	1.645383
			(2.099652)
Eugene	-	-	0.4143313
			(1.098362)
Salem	-	-	1.6548*
			(.8565737)
Constant	4.105975	4.375279	5.251122
	(2.588091)	(2.970524)	(3.419198)
Observations	36	36	36
R^2	0.8091	0.8093	0.8148

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

In all three models median county income and population density are neither strong nor significant predictors of the proportion of hybrid and electric vehicles registered in a county. This result is not surprising because both variables are very crude indicators. Median county income cannot reveal whether or not the wealthiest residents of a county are more likely to own hybrid or electric vehicles. Likewise, county population density cannot distinguish between a county with a few very dense areas and a county with moderate but evenly dispersed population density. The proportion of county residents with a college degree has a positive and statistically significant effect on the proportion of hybrid and electric vehicles registered in a county, as was expected. Counties that contain big cities do tend to have a higher proportion of hybrid and electric vehicles. Although these effects are generally not statistically significant, they do suggest that hybrid and electric vehicles are more common in the densely populated urban areas to which they are best suited. The proportion of registered voters who belong to the Pacific Green Party has a very strong and significant effect on the proportion of hybrid and electric vehicles registered in a county. This suggests that a consumer with strong environmental ideology is more likely to own a hybrid or electric vehicle, even if he lives in an area to which the vehicle is not ideally suited.

CHAPTER SIX

CONCLUSION

The models estimated in this analysis reveal that consumers value the hybrid vehicle label not just for the information it provides on vehicle fuel consumption and emissions, but also for the information it conveys about a vehicle's owner. Hedonic price analysis was applied to data on new cars, trucks, SUVS, minivans, and vans available in the United States and Canada in 2012. The results showed that vehicle price tends to decrease with vehicle size, and to increase with power, performance, comfort, luxury status, fuel consumption, and cleaner emissions. The hedonic price analysis also demonstrated that, for given levels of fuel consumption and emissions, consumers will pay more for a vehicle that bears the hybrid label. County-level data from Oregon were also analyzed for the determinants of the proportion of hybrid and electric vehicles to gas vehicles. The results showed that the proportion of hybrid and electric vehicles to gas vehicles in a county increases with the proportion of county residents who have a college degree and is not affected by median county income or county population density. The presence of a large city in a county does increase the proportion of hybrid and electric vehicles to gas vehicles in the county. The Oregon analysis also demonstrated that communities containing consumers who express strong environmental sentiments are likely to have greater proportions of hybrid and electric vehicles, even if those communities are not located in areas ideally suited to hybrid and electric cars. Taken in conjunction, the hedonic price analysis results and the Oregon analysis results suggest that consumers will pay more for a vehicle that bears the hybrid label because that label increases the owner's social status in the environmental community and conveys to others the strength of the owner's environmental commitment. It is important to recognize that eco-labels, such as the hybrid vehicle label, do not necessarily convey the same message to producers and consumers. The increasing popularity of eco-labeled products cannot be simply and universally extrapolated as a measure of how much consumers care about the environment. Each eco-labeled product should be examined individually to determine what unobserved attributes that distinguish the eco-labeled product from non-labeled products consumers may value.

APPENDICES

Appendix A

Distribution of Vehicles by Maker

Table 7. Vehicle Distribution by Maker.

Maker	Number of Vehicles	Percentage of Total Vehicles
Acura	24	1.26
Aston Martin	38	1.99
Audi	43	2.25
Bentley	2	0.10
BMW	52	2.72
Buick	28	1.47
Cadillac	53	2.78
Chevrolet	144	7.54
Chrysler	21	1.10
Dodge	36	1.89
Fiat	6	0.31
Fisker	3	0.16
Ford	148	7.75
GMC	96	5.03
Honda	96	5.03
Hyundai	69	3.61
Infiniti	32	1.68
Jaguar	16	0.84
Jeep	32	1.68
Kia	49	2.57
Lamborghini	7	0.37
Land Rover	6	0.31
Lexus	26	1.36
Lincoln	13	0.68
Maserati	5	0.26
Maybach	4	0.21
Mazda	59	3.09
Mercedes-Benz	56	2.93
Mini	13	0.68
Mitsubishi	30	1.57
Nissan	115	6.02
Porsche	38	1.99
Ram	30	1.57
Rolls-Royce	5	0.26
Saab	18	0.94
Scion	13	0.68
Smart	3	0.16
Subaru	76	3.98
Suzuki	40	2.10
Toyota	128	6.71
Volkswagen	221	11.58
Volvo	15	0.79
Total	1,909	100.00

<u>Appendix B</u>

<u>Results for Regressions of Price on Base Model with Country of Origin and Base Model with Maker</u>

Table 8. Full Regression Results for Price on Base Model with Country of Origin.

Price	**Estimate**	**Standard Error**
Curb weight	-9.11918**	3.595859
Engine size	9,292.461***	1,671.437
Turning diameter	-446.363	273.1122
Leather	15,270.64***	1,472.897
Luxury	3,419.611	3,409.668
Fuel consumption	13,901.47***	3,718.053
Air pollution	2,958.368***	843.0743
Hybrid	26,709.02***	4,936.517
England	83,595.75***	10,298
Germany	30,242.59***	4,057.707
Italy	86,798.01***	16,294.11
Japan	6,680.948***	2,2021.286
South Korea	10,721.53***	2,846.199
Sweden	11,401.5***	3,879.973
Constant	-41,146.4**	16,197.61

Note: N = 1909. R^2 = 0.5792. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The United States is the omitted country of origin.

Table 9. Full Regression Results for Price on Base Model with Maker.

Price	**Estimate**	**Standard Error**
Curb weight	-7.086072**	3.144758
Engine size	7,563.483***	973.0125
Turning diameter	-543.7902***	149.4134
Leather	8,331.136***	738.9328
Luxury	5,109.212	4,570.404
Fuel consumption	8,583.9***	2,930.248
Air pollution	1,508.646***	379.7089
Hybrid	16,698.26***	3,299.043
Acura	-1,234.594	1,255.263
Aston Martin	119,596.3***	10,768.71
Audi	27,944.72***	5,424.348
Bentley	113,754.4***	2,688.285
BMW	24,394.31***	2,881.152
Buick	-1,031.878	4,899.235
Cadillac	2,634.405	1,741.367
Chevrolet	-5,840.014	4,540.085
Chrysler	-7,909.896	5,224.383
Dodge	-7,275.666	5,010.518
Fiat	4,232.208	4,712.226
Fisker	125,233.8***	15,523.18
Ford	-2,235.769	4,800.455
GMC	-6,144.355	4,416.253
Honda	152.1608	4,614.362
Hyundai	-2,918.153	4,403.16
Infiniti	-4,071.918**	1,665.955
Jaguar	30,276.27***	6,045.537
Jeep	-7,129.091	4,703.414
Kia	-1,124.994	4,659.816
Lamborghini	165,869.6***	23,569.27
Land Rover	1,827.126	5,433.256
Lexus	15,975.25	11,208.12
Lincoln	223.4545	2,261.368
Maserati	70,732.09***	4,859.548
Maybach	358,742.3***	17,753.69
Mazda	-3,647.928	4,500.444
Mercedes-Benz	31,673.49***	4,734.328
Mini	12,384.55***	4,639.779
Mitsubishi	-1,846.423	4,574.516
Nissan	-6,013.241	4,552.193
Porsche	45,516.82***	6,358.503
Ram	-11,524.66**	4,767.446
Rolls-Royce	296,564.2***	38,345.92
Saab	4,549.042***	1,752.956
Scion	-2,735.509	4,450.642
Smart	454.1735	4,586.941
Subaru	-2,147.328	4,492.821
Suzuki	-3,720.213	4,415.23
Toyota	-4,581.28	4,484.607
Volkswagen	5,606.531	4,584.114
Constant	4,073.944	8,624.46

Note: N = 1909. R^2 = 0.8540. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Volvo is the omitted maker.

REFERENCES

Asche, F., Larsen, T. A., Smith, M. D., Sogn-Grundvag, G., & Young, J. A. (2013). Pricing of eco-labels for salmon in U.K. supermarkets. *Duke Environmental and Energy Economics Working Paper Series*, EE 13-02. Retrieved from http://sites.nicholasinstitute.duke.edu/environmentaleconomics/files/2013/05/WP-EE-13-02.pdf

Atkinson, S. E., & Halvorsen, R. (1984). A new hedonic technique for estimating attribute demand: An application to the demand for automobile fuel efficiency. *Review of Economics and Statistics, 66,* 417-426.

Baltas, G., & Saridakis, C. (2010). Measuring brand equity in the car market: A hedonic price analysis. *Journal of the Operational Research Society, 61*, 284-293.

Beresteanu, A., & Li, S. (2011). Gasoline prices, government support, and the demand for hybrid vehicles in the United States. *International Economic Review, 52*, 161-182.

Blend, J. R., & van Ravenswaay, E. O. (1999). Measuring consumer demand for ecolabeled apples. *American Journal of Agricultural Economics, 81*, 1072-1077.

Broder, J. M. (2004, November 28). 2005 Honda Accord Hybrid: Greening without the preening. *The New York Times*. Retrieved from http://www.nytimes.com/2004/11/28/automobiles/28AUTO.html

Court, A. T. (1939). Hedonic price indexes with automotive examples. In C. F. Roos (Ed.), *The dynamics of automobile demand* (pp. 99-117). New York, NY: The General Motors Corporation.

Couton, C., Gardes, F., & Thepaut, Y. (1996). Hedonic prices for environmental and safety characteristics and the Akerlof effect in the French car market. *Applied Economics Letters, 3,* 435-440.

Cowling, K., & Cubbin, J. (1971). Price, quality, and advertising competition: An econometric investigation of the United Kingdom car market. *Economica, 38*, 378-394.

Delmas, M. A., & Grant, L. E. (2010). Eco-labeling strategies and price-premium: The wine industry puzzle. *Business & Society*. doi:10.1177/0007650310362254

Douglas, E. J., Glennon, D. C., & Lane, J. I. (1993). Warranty, quality and price in the U.S. automobile market. *Applied Economics, 25*, 135-141.

Dreyfus, M. K., & Viscusi, W. K. (1995). Rates of time preference and consumer valuations of automobile safety and fuel efficiency. *Journal of Law & Economics, 38*, 79-105.

Dunham, W. R. (1997). Are automobile safety regulations worth the price: Evidence from used car markets. *Economic Inquiry, 35*, 579-589.

Ecolabel Index. (2013). *Ecolabel Index: Who's deciding what's green?* Retrieved from http://www.ecolabelindex.com

Espey, M., & Nair, S. (2005). Automobile fuel economy: What is it worth? *Contemporary Economic Policy, 23,* 317-323.

Goodman, A. C. (1983). Willingness to pay for car efficiency: A hedonic price approach. *Journal of Transport, Economics and Policy, 17*, 247-266.

Griliches, Z. (1971). Hedonic price indexes for automobiles: An econometric analysis of quality change. In Z. Griliches (Ed.), *Price indexes and quality change* (pp. 55-87). Cambridge, MA: Harvard University Press.

Halbright, R., & Dunn, M. (2010). *Case study: The Toyota Prius. Lessons in marketing eco-friendly products*. Retrieved from http://academia.edu/239996/Prius_Marketing_Case_Study

Kahn, M. E. (2007). Do greens drive Hummers or hybrids? Environmental ideology as a determinant of consumer choice. *Journal of Environmental Economics and Management, 54,* 129-145.

Kelley Blue Book. (2013). *Frequently asked questions: New car pricing*. Retrieved from http://www.kbb.com/company/faq/new-cars

Kiso, T. (2010). *Pricing automobile fuel economy: A new hedonic approach.* Retrieved from http://www.webmeets.com/files/papers/WCERE/2010/1673/Pricing%20Automobile%20Fuel%20Economy%2006.21.10.pdf

Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy, 74,* 132-157.

Maynard, M. (2007, July 4). Toyota's hybrid car more than a mixed success. *The New York Times*. Retrieved from http://www.nytimes.com/2007/07/04/business/worldbusiness/04iht-hybrid.4.6491389.html?_r=0

Mertens, Y., & Ginsburgh, V. (1985). Product differentiation and price discrimination in the European community: The case of automobiles. *Journal of Industrial Economics, 34*, 151-166.

Nimon, W., & Beghin, J. (1999). Are eco-labels valuable? Evidence from the apparel industry. *American Journal of Agricultural Economics, 81*, 801-811.

Ohta, M., & Griliches, Z. (1976). Automobile prices revisited: Extensions of the hedonic hypothesis. In N. E. Terleckyj (Ed.), *Household production and consumption* (pp. 325-398). New York, NY: National Bureau of Economic Research.

Ohta, M., & Griliches, Z. (1986). Automobile prices and quality: Did the gasoline price increases change consumer tastes in the U.S.? *Journal of Business & Economic Statistics, 4,* 187-198.

Oregon Blue Book. (2013). *Local government*. Retrieved from http://bluebook.state.or.us/local/index.htm

O'Reilly Auto Parts. (2013). *Compression ratios explained*. Retrieved from http://www.oreillyauto.com/site/app/newsfeed/detail?article=800753678

Organic Trade Association. (2011a). *Organic industry survey*. Brattleboro, VT: Author.

Organic Trade Association. (2011b). *Seventy-eight percent of U.S. families say they purchase organic foods*. Retrieved from http://www.organicnewsroom.com/2011/11/seventyeight_percent_of_us_fam.html

Owen, A., Videras, J., & Wu, S. (2010). Identity and environmentalism: The influence of community characteristics. *Review of Social Economy, 68*, 465-486.

Pacific Green Party. (2012). *About the Pacific Green Party*. Retrieved from http://www.pacificgreens.org/category-pacific-green-party/about-the-pacific-green-party

Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of Political Economy, 82*, 34-55.

Sims Gallagher, K., & Muehlegger, E. (2011). Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology. *Journal of Environmental Economics and Management, 61,* 1-15.

Statesman Journal Data Center. (2012a). *Oregon voter registration totals by county* [Data file]. Retrieved from http://community.statesmanjournal.com/blogs/data/2012/03/30/oregon-voter-registration-totals-by-county

Statesman Journal Data Center. (2012b). *Vehicles in Oregon counties* [Data file]. Retrieved from http://community.statesmanjournal.com/blogs/data/2012/04/06/vehicles-in-oregon-counties

Thompson, R. S. (1987). New entry and hedonic price discounts: The case of the Irish car market. *Oxford Bulletin of Economics and Statistics, 49*, 373-384.

Triplett, J. E. (1969). Automobiles and hedonic quality measurement. *Journal of Political Economy, 77*, 408-417.

Triplett, J. E. (1986). The economic interpretation of hedonic methods. *Survey of Current Business, 66*(1), 36-40.

U. S. Census Bureau. (2013). *Oregon quickfacts from the U. S. Census Bureau*. Retrieved from http://quickfacts.census.gov/qfd/states/41000.html

U. S. Environmental Protection Agency. (2013). *Green vehicle guide: About the ratings*. Retrieved from http://www.epa.gov/greenvehicles/Aboutratings.do

U. S. Environmental Protection Agency and U. S. Department of Energy. (2013). *Fuel economy guide, model year 2012*. Washington, DC: U. S. Government Printing Office.

Vehicle List. (2013). Car database 2012 [Data file]. Retrieved from http://thevehiclelist.com