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Analysis

The value of environmental status signaling☆

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ABSTRACT

How much are consumers willing to pay to signal their environmental consciousness? We identify the signaling value of an environmental public good by focusing on hybrid cars and exploiting the physical uniqueness of the Toyota Prius relative to hybrids that look identical to their non-hybrid counterparts. We deploy a quasi-experimental hedonic model to estimate this willingness to pay. We find that, controlling for observable and unobservable factors, the Prius commands an environmental signaling value of $587 or 4.5% of its value. Our research provides lessons for economists and policymakers, and contributes to the literature on identifying signaling values.

1. Introduction

How much are consumers of environmental public goods willing to pay to signal their environmental consciousness? How much are consumers willing to pay to satisfy other behavioral demand motives for environmentally friendly products? A large amount of environmental economic and social research in recent years has revolved around substantial anecdotal evidence that consumption of environmental public goods is driven, at least in part, by behavioral motives. Theoretical explanations for growing demand for environmentally friendly products typically include the now classic models of altruism (e.g., Bergstrom et al., 1986) and impure altruism (e.g., Andreoni, 1989),as well as alternative behavioral hypotheses that include guilt (Kotchen, 2009; Jacobsen et al., 2012). In the case of highly visible environmentally friendly products, such as hybrid cars or solar panels, researchers have recently begun to explore social status signaling as an important demand driver (Dastrup et al., 2012; Sexton and Sexton, 2014).

The anecdotal evidence and theoretical explanations are compelling characterizations of growing consumer demand for environmental public goods, yet there is a dearth of empirical evidence quantifying the behavioral components of such demand.[1] The reason for this lack of evidence is that behavioral demand components are unobservable and often confounded by a multitude of unobservable related factors, making econometric identification of such demand components challenging. There do not exist many opportunities for researchers to construct a reliable model capable of controlling for such confounding factors. It is also likely that demand for different goods is motivated

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[1] Recent exceptions include Dastrup et al. (2012), Jacobsen et al. (2012) and Sexton and Sexton (2014). We provide a detailed review of related literature in Section 2.

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for different reasons, making generalizations of any econometric estimates difficult.

We provide a plausible empirical strategy for identifying environmental social status effects, and estimate consumer willingness to pay for highly visible environmental public goods in order to signal their environmental awareness. We contend that social status is a relevant demand component for any environmental product that is obviously visible to others: solar panels, reusable products, and hybrid cars are important examples. To put this in the context of other environmental public goods, consumption of renewable electricity purchased from the grid is not likely to be driven significantly by concern for social status as consumption of renewable energy is not generally visible by others. Evidence of social status as an important demand component for visible environmental public goods includes the disproportionate share of ownership of the Toyota Prius relative to other hybrid cars, holding constant confounding effects such as brand loyalty or Prius marketing initiatives (Sexton and Sexton, 2014). The Prius, as documented by Sexton and Sexton (2014), was carefully designed by Toyota to be visually distinct from all other passenger vehicles making it highly visible as a hybrid car. Furthermore, Heffetz (2011) finds that cars are one of the most visible consumption goods available to households.

To identify the social status demand components of visible environmental public goods, we exploit the fact that the Toyota Prius is the only visually distinct hybrid car. All other hybrid cars are extensions of other conventional gasoline engine models, the most popular model being the Honda Civic hybrid. These non-Prius hybrids are only identifiable as hybrids via the small 'hybrid' label on the rear of the car.[2] Yet, we expect that any non status-seeking hybrid consumer is indifferent between a Prius and non-Prius hybrid, holding constant any confounding effects such as brand loyalty or mechanical, luxury, and safety features. In other words, if demand for the Toyota Prius is driven, at least in part, by concern for social status, we expect that the marginal value of a Toyota Prius is significantly higher than the marginal value of all other hybrids relative to conventional gasoline engine vehicles, controlling for relevant observable and unobservable confounding factors. Our econometric setup controls for any non-status behavioral demand drivers that have received much attention in recent environmental economics research.

We adopt a quasi-experimental hedonic pricing model to estimate the marginal willingness to pay for environmental status signaling associated with a Toyota Prius.[3] Our interest is on an indicator for Toyota Prius that captures any price premium specific to the Prius. The hedonic setup allows us to account for potential observable and unobservable confounding factors that influence the price of a car, such as, fuel efficiency, safety and luxury features, mechanical specifications, or brand loyalty.[4] We control for any unobservable non-status demand drivers common to all hybrid vehicles (e.g., altruism, warm-glow, or guilt) by including a general hybrid indicator in our hedonic regressions. Hence, our quasi-experimental hedonic setup allows us to control for both observable and unobservable confounding factors that, if unaccounted for, might bias our estimates of the status signaling value of the Prius. We consider other Prius-specific unobservable demand drivers (e.g., Toyota reliability, Prius marketing, etc.) as potential confounding factors in our analysis; given marketing research and discussion of social status effects, we argue that these effects are not likely contaminants of our status signaling estimates. Hence, given our set of controls, we interpret statistical significance of the Toyota Prius indicator to be evidence quantifying the status signaling value of the Prius.

The data is a cross-section of consumer vehicles obtained from the 2009 National Household Travel Survey administered by the United States Department of Transportation. We obtain zip-code specific market prices for each vehicle in our sample from the Kelly Blue Book database of used car prices to exploit both the year and odometer reading unique to each vehicle in our sample, as well as variation in local market equilibrium prices. Technical specifications that form the basis for our set of hedonic control variables come from both the Kelly Blue Book database and the Wards Automotive Yearbook. Our final combined dataset contains 36,167 cross-sectional observations, of which 1,222 are Toyota Prius and 1,847 are hybrids. We further classify observations into census divisions and core-based statistical areas, which facilitates regional and local market-specific analyses in addition to a national level analysis.

Our quasi-experimental hedonic model yields a positive and significant marginal value for the Toyota Prius of approximately $587. This means that, controlling for mechanical differences across vehicles, accounting for fuel efficiency benefits of the Prius (and hybrids in general), as well as general behavioral motivation for purchasing hybrids (e.g., altruism), the Toyota Prius has on average a social status signaling value of $587. To put this number in perspective, the average marginal value of hybrids in general, controlling for confounding differences across vehicles, is about $1954. Since our general hybrid indicator potentially captures a variety of demand drivers influencing the demand for hybrids, whereas the Prius indicator only identifies the social status signaling effect net of other unobservable components, it is reasonable that our hybrid estimate is substantially larger than our Prius estimate. We consider a variety of different econometric specifications and market definitions to explore the robustness of this result, and find that, in general, the Prius estimate is significant and ranges from $391–$1012 and the hybrid estimate ranges significantly from $1521–$2833. These estimates imply that, on average, the status signaling value of the Toyota Prius accounts for approximately 4.5% of its total value, while the general hybrid behavioral components account for approximately 14% of the average value of a hybrid.

Our paper has several important implications. First, our econometric setup and identification constitute an important contribution into the empirical literature quantifying behavioral motives for consumer demand in general, providing a unique opportunity to reliably measure the value of environmental social status signaling. Second, our research has clear implications in the environmental literature, providing quantitative measures of consumer demand components for environmental public goods, evidence that social status in part drives consumption of visible environmental public goods, as well as a quantitative measure of the relative value of social status signaling and other behavioral demand drivers. Finally, our empirical results are of interest to policymakers interested in the proliferation of hybrid car adoption as such policies rely on understanding the drivers of consumer demand for hybrid vehicles.

2. Review of Relevant Literature

Our work is most closely related to research focused on behavioral demand drivers of hybrid vehicle consumption.[5] For instance, Heutel and Muehlegger (2012) provide a model of hybrid technology diffusion under uncertainty regarding the quality of hybrid technology, and Narayanan and Nair (2013) provide evidence that Prius demand is, in part, driven by social influence. Sexton and Sexton (2014) provide an empirical model that is most closely related to our work. Their

[2] Sexton and Sexton (2014) explore identification of a social status demand component for the Toyota Prius based on the same general insight, however their identification strategy and empirical model is substantially different from ours. We provide more explicit details of how our work relates to theirs below.

[3] Our model is quasi-experimental because identification of the environmental status effect comes through comparison of the Toyota Prius price premium to the price premium of a control group of hybrid vehicles.

[4] Recently, hedonic models have been applied in the context of the automobile market by, for instance, Espey and Nair (2005), and the references cited therein.

[5] See, also, work on hybrid vehicle adoption in the context of tax policy (Chandra et al., 2010; Beresteanu and Li, 2011; Gallagher and Muehlegger, 2011) and consumer types (Kahn, 2007; Kahn and Morris, 2009; Gallagher and Muehlegger, 2011); behavioral demand drivers in an environmental context (Clark et al., 2003; Kotchen and Moore, 2007; Allcott, 2011; Jacobsen et al., 2012); and theoretical models of behavioral demand for environmental consumption (Kotchen, 2005, 2006, 2009; Delgado and Khanna, 2015).

hypothesis and motivation is similar to ours: the Prius provides the only hybrid vehicle option for signaling environmental consciousness. In their empirical framework, the Honda Civic hybrid is used as a control group for unobserved factors that are unique to all hybrids. Their main contribution is to establish a significantly disproportionate share of Toyota Prius registration in relatively greener communities, through which they can calculate a Prius price premium which they attribute to status signaling. They calculate a Prius status signal in the range of $430 to $4200.

The empirical framework of Sexton and Sexton (2014) is, however, substantially different from ours. They use market shares of the Prius and Civic hybrid in different communities that may differ in overall attitudes towards environmental protection as an indicator of relative signaling value. They provide compelling arguments that the Prius has a relatively higher value in a community with a relatively stronger preference for environmental amenities. Hence, they search for a disproportionate share of Prius ownership in relatively greener communities that, conditional on other factors, is evidence of a social status value of the Prius.

One difference between our approach and the approach deployed by Sexton and Sexton (2014) is that their model does not directly provide an econometric estimate of the signaling value of the Prius. They assume that the price elasticity of the Toyota Prius is approximately the same as those of small conventional engine sedans, such as the Toyota Corolla. While not unreasonable, this assumption is untested. The advantage of our hedonic approach is that we can avoid this assumption and directly estimate the signaling value of the Prius using a standard methodology. Further, our study is not limited to two particular geographical areas; we use a national sample of car ownership and are able to identify the signaling value of the Prius across different regions within the United States.

Our work is also closely related to Dastrup et al. (2012), who estimate the status signaling value of solar panels in California homes. Like us, Dastrup et al. (2012) deploy a hedonic model with an indicator for solar panels (in our case, the indicator is for Toyota Prius), however unlike us they do not control for alternative behavioral demand drivers that may confound their estimates of the status signal (e.g., altruism or warm-glow). They estimate that the social status signaling value of solar panels is approximately 3.5% of the market price of the home.

3. Identification and Econometric Strategy

3.1. Hypothesis and Identification

Our hypothesis is that demand for visible environmental public goods is driven, in part, by social status-seeking desires. In general, this hypothesis is not testable because it is challenging to separate out or account for a variety of unobservables that are also likely to influence demand. However, in the case of the Toyota Prius, it is possible to identify the environmental status value separately from other confounding factors. Hence, we refocus our hypothesis to the following testable hypothesis:

Hypothesis. There is a status-seeking component to the demand for the Toyota Prius.

Our identification of the status-seeking value of the Toyota Prius is grounded in the observation that of all available hybrid vehicles, the Toyota Prius is the only visually unique hybrid, as all other hybrids are derived from a visually identical conventional engine vehicle.[6] Consider, for example, the Honda Civic hybrid as being representative of all non-Prius hybrids: the only feature identifying the Honda Civic hybrid from a conventional Honda Civic is the label on the rear of the vehicle stating that the model is a hybrid. Passers-by do not generally recognize the Civic hybrid as being a hybrid; hence, the Civic hybrid does not provide much opportunity for a status-seeking consumer to satiate their desires to signal their environmental consciousness. All else being equal, a status driven consumer will not purchase the Honda Civic hybrid, and will instead choose to purchase the Toyota Prius.

This insight provides the justification for considering differences in prices of the Toyota Prius relative to other hybrids, holding constant differences in mechanical, safety, and luxury specifications, as well as unobservable brand effects (e.g., loyalty, reputation). Considering a variety of plausible motives driving purchases of hybrid vehicles — social status, altruism, warm-glow, guilt, and fuel efficiency — we contend that each motive, with the important exception of status signaling, can be satisfied via consumption of any hybrid (Prius or non-Prius). Consider, for example, an altruistic consumer who wishes to purchase a hybrid vehicle in order to contribute to improved environmental quality. Physical vehicle characteristics and tastes being held equal, such a consumer would be indifferent between purchasing a Prius or any non-Prius hybrid, as the visual uniqueness of the Prius is of no general value to this consumer. The same is true for any possible motive, except for status signaling. Therefore, controlling for the demand drivers common to all hybrids (i.e., common to both Priuses and non-Priuses), provides an important means of differencing out status-signaling demand from other drivers of hybrid demand.

We emphasize the generality of this identification strategy, as our use of hybrids as a control group for unobservable factors influencing demand for the Prius is in no way restricted to the several factors listed above. Indeed, our use of hybrids as a control is capable of accounting for any unobservable factors that may confound identification of the Prius status signal, so long as these unobservable factors are common to all types of hybrids. After accounting for both observable and unobservable factors influencing the demand for the Toyota Prius, we argue that statistical evidence that the Toyota Prius continues to command a relatively higher price is evidence of a statistically significant social status signaling value.

3.2. Econometric Strategy

Our empirical model is a quasi-experimental hedonic pricing model for automobiles given a vector of control variables that account for differences in the observed market prices of different cars. Quasi-experimental econometric methods have begun to receive considerable attention in the hedonic pricing literature (Parmeter and Pope, 2013). While hedonic methods have been used to extract the implicit price of a single attribute from the overall price of a commodity (Rosen, 1974; Taylor, 2003; Palmquist, 2005; Parmeter and Pope, 2013), one potential shortcoming is that the standard model is unable to generally account for unobserved factors that may influence prices. Quasi-experimental methods are able to control for certain unobserved factors by comparing a treatment group to a control group, where the control group is able to account for unobserved factors that are exogenous to treatment and common to both treatment and control groups. Under this assumption, a quasi-experimental hedonic approach can be a powerful method for controlling for both observable and unobservable factors influencing the commodity price.

A standard hedonic regression model defines the price of the automobile, P_i, to be a function of a vector of vehicle attributes, X_i, for some conditional mean response and observation index $i = 1,2,\ldots,n$. We consider a quasi-experimental version of a standard semi-log specification (Boyle et al., 1999; Heintzleman and Tuttle, 2012) as our primary specification, defining X_i to include mechanical specifications, safety features, luxury attributes, fuel efficiency rating, odometer reading, year built, and indicators for vehicle make (we provide complete details below). Define D_P as a binary indicator for the Toyota Prius and D_H as

[6] The one exception is the Honda Insight, which was the first hybrid electric passenger vehicle introduced in the US consumer market. This two-seater vehicle proved to be very unsuccessful and Honda stopped production after a few years. There are no Honda Insights in our sample.

an analogous indicator for all hybrids, including the Toyota Prius. Then, we formulate our model as

$$ln\, P_i = \beta_0 + \beta_1 D_P + \beta_2 D_H + \beta_3 X_i + \epsilon_i. \quad (1)$$

In this specification, estimates of the marginal willingness to pay for each attribute is recovered by multiplying the estimated coefficients, $\hat{\beta}$, by P_i.

Given our identification strategy and use of the general hybrid indicator to account for any (non-status) demand drivers common to all hybrid vehicles, β_1 defines the status signaling value of the Prius. Hence, our primary focus is on the estimate of β_1, and a standard t-test of the null hypothesis that $\beta_1 = 0$ provides a formal statistical test of our primary hypothesis. Of independent interest is the parameter β_2, as this parameter captures the non-status value of a hybrid, holding constant the observables defined in X_i. That is, an estimate of β_2 provides a measure of the bundled value of other, non-status, behavioral hybrid demand drivers. In addition to testing the individual significance of both β_1 and β_2, a comparison of the relative magnitudes of these parameters provides insight into the relative strength of the social status signaling value compared to the value of all other hybrid demand drivers.

One important aspect of hedonic modeling that deserves some attention is the definition of the market in which to conduct the empirical study (Parmeter and Pope, 2013). In our case, there are two plausible ways to define the market: a national market and a local (or regional) market. One view is that vehicle prices are essentially national prices. Manufacturer Suggested Retail Prices are set nationally. Further, unlike in the housing market, the value of any vehicle is not likely to vary regionally as the value is typically determined only by vehicle-specific factors, and not additionally by local or regional factors. Hence, there is no particular reason to believe that identical cars will have different equilibrium market prices in different parts of the country. In this view, a nationally defined market is appropriate.

An alternative view is that consumers are likely to search within the nearest metropolitan area for vehicles, but are not likely to look across different states or outside their closest metropolitan area. This conjecture implies that there may be regional or local differences in the equilibrium market value of otherwise identical vehicles that can be exploited to obtain more precise estimates of the parameters in the model. In this case, the appropriate size of the market for cars is the regional or local metropolitan level. As we discuss in Section 4, one advantage of our dataset is that we have access to the core-based statistical area location of each observation that can be exploited to estimate approximately city-level regressions. Hence, we begin our analysis at the national level to obtain a preliminary set of regression results, and then refine our analysis by considering both census division and core-based statistical area regressions. Indeed, one additional advantage of considering multiple markets is that we can compare estimates across markets to investigate heterogeneity in the signaling value of the Prius.

Finally, we acknowledge that a potential shortcoming of the model specified in (1) and the description of our identification strategy in general is that we have not yet addressed any potential confounding factors that are Prius specific. As stated, our controls are only able to account for unobservable factors that are common to all hybrids. We defer this discussion until Section 7.

4. Data

The data comes from three different sources: the 2009 National Household Travel Survey (NHTS) conducted by the United States Department of Transportation Federal Highway Administration, the 2002–2009 Wards Automotive Annual Yearbooks Model Car US Specifications and Prices tables (WARDs), and the Kelly Blue Book online vehicle pricing database (KBB). Each observation in our final dataset represents a vehicle from the NHTS survey, supplemented by vehicle price and technical specification data obtained from both WARDs and KBB. Both the NHTS (2001 version) and WARDs data were used previously by, for example, Bento et al. (2009).

4.1. National Household Travel Survey

Our primary data source is the vehicle file from the 2009 NHTS survey (version 2.1).[7] The survey reports the make, model, year, and odometer reading for each vehicle owned by each household included in the survey. We obtained from the United States Department of Transportation Federal Highway Administration confidential zip code information for each household in the survey, which we use in conjunction with the KBB database to gather local market specific prices for each automobile in our sample.

The initial NHTS vehicle file consists of 309,163 vehicles. Given the focus of this paper, we restrict our sample to standard passenger vehicles, and eliminate vehicles such as vans, SUVs, trucks, and motorcycles. The NHTS provides the official vehicle make and model codes as defined by the National Automotive Sampling System. Since these codes allow us to merge the NHTS dataset with other vehicle information from KBB and WARDs, we remove any vehicle with a missing make or model code. Since the KBB relies upon the vehicle specific odometer readings along with the make, model, and year to determine market price, we also drop any observations that report missing odometer readings or abnormal responses such as negative values, readings less than 100 miles on cars older than two years, or readings greater than 300,000 miles.

We restrict our sample to vehicles with model years 2002–2009, since the oldest hybrid vehicle in the data is from 2002, to ensure that the sample of conventional engine vehicles corresponds to the hybrid electric vehicles. We further eliminate any observations with missing information for the NHTS hybrid indicator, as well as any natural gas, diesel, or flex-fuel vehicles.

4.2. WARDs Automobile Specifications

We turn to the WARDs automotive guides for detailed vehicle specifications on all vehicles in our NHTS sample. The lists of vehicles provided in these tables are extensive; for example, in 2008 there are 11 different Toyota Camry options, including the Camry hybrid, and these models differ by engine type, transmission type, and interior trim packaging. Since the NHTS survey does not specify which particular version of each make-model-year combination is reported, we follow Bento et al. (2009) and assume that all households with a traditional gasoline engine own the base model for each make-model-year combination (i.e., a standard transmission and the lowest MSRP reported in WARDs). It is important to bear in mind that this assumption to use the base model is fairly innocuous given our hedonic setup: the virtue of the hedonic control variables is to render each vehicle observation statistically identical, so that our estimate of the Prius and hybrid effects are unbiased. We then obtain detailed specifications on mechanical, luxury, and safety features for each vehicle in the dataset. We further restrict our sample of vehicles to those in the first seven market segments that are not deemed to be luxury class vehicles (this removes, for example, brands such as Lexus, BMW, Mercedes, and vehicles such as the Chevrolet Corvette, or Dodge Thunderbird). We match the information from WARDs with the information provided by the NHTS, and remove any unmatched observations between the WARDs base model vehicle specification information with the NHTS vehicle information.

4.3. Kelly Blue Book

In order to estimate a hedonic price equation, we need observation specific prices for each car in our sample. To obtain these prices, we

[7] This data is available online at the Data Center website of the National Highway Travel Survey located at http://nhts.ornl.gov/download.shtml.

turn to the KBB that provides current resale values for each car in our dataset, which allows us to use detailed information on odometer readings as well as household zip codes to identify unique, local market specific prices.[8] Our KBB data were retrieved during the week of April 26, 2013.

In using the KBB resale values to measure the equilibrium market price of a vehicle, we make two assumptions. First, we presume that any signaling value that exists in the retail price of a brand new Prius also exists in the resale market. The desire to signal environmental consciousness is not unique to new car owners, and a used Prius may be a viable option for consumers wishing to signal their environmental consciousness without purchasing a brand new vehicle. Further, differences in new and used car prices reflect physical depreciation in the used car, however the visual uniqueness that affords the Prius a status signal as a hybrid car does not depreciate. Conditioning on our hedonic controls should account for any differences between new and used car prices, and should not affect our ability to identify and estimate the Prius status signal.

Second, we recognize that current market resale values may be sensitive to external factors, such as current or recent gasoline prices. While this is a valid concern, sensitivity of market prices to current gasoline prices is not unique to hybrids or the Prius, and any possible manifestation of this effect in our data will affect the used car price for all fuel efficient vehicles, not just the hybrids. One important control variable in our regressions is the miles per gallon rating on each vehicle. If current gasoline prices are an important factor in determining recent market values of the vehicles in our dataset, such an effect would be in part captured by the miles per gallon variable. In the worst case, if current gasoline market trends did disproportionately affect hybrids in our sample, this effect would be captured by our hybrid control indicator, and would not hamper our ability to identify and estimate the status signaling value of the Prius. That is, there is no particular reason to believe that this issue would affect our estimate of the signaling value of the Prius.

We also use the KBB to return several additional vehicle attributes, for instance, trim features such as cruise control, air conditioning, airbags, and standardized estimates of vehicle fuel efficiency (miles per gallon). The WARDs database provides estimates for fuel efficiency, however the WARDs estimates do not account for the change in measurement standards that occurred in 2008. In that year, the Environmental Protection Agency adjusted the standards for measuring fuel efficiency to incorporate changes in average speed, air conditioning usage, and exterior temperatures. In light of this change, we utilize the fuel efficiency information reported in the KBB which is measured in post-2008 miles per gallon standards and is consistent across all model years (including years prior to 2008).

We eliminate any vehicles that are missing either price or fuel efficiency information from the KBB. We then merge the KBB information with the WARDs and NHTS vehicle data and eliminate any unmatched vehicles. We are left with a total sample of 36,167 cars, of which 1847 are hybrid electric vehicles, and 1222 of the hybrids are Toyota Prius hybrids.

4.4. Data Summary

4.4.1. Regression Controls

Identifying a Prius premium that can be reliably attributed to status signaling hinges upon a complete set of hedonic controls that render all cars in our sample statistically equivalent, with the exception of any premium unique to all hybrids and/or specific to the Prius. While both the WARDs and KBB sources returned a wealth of measures on vehicle attributes, many of these measures are highly correlated reflecting the fact that many features come bundled together by the auto manufacturer. For example, many performance or luxury features come bundled in a performance or luxury package, and are not generally available separately. Including all of these measures in our regression simultaneously leads to multicollinearity problems, causing many regressors to take unexpected signs and significance (Espey and Nair, 2005). To address this issue, we pared down our set of controls to carefully account for important dimensions of vehicle value, while avoiding any multicollinearity issues that might compromise our analysis. Our procedure for selecting which variables to include is done both conceptually by eliminating many measures that seem redundant based on common vehicle attribute packages, as well as examination of variance inflation factors as statistical reassurance that our model specification is not riddled with a high degree of multicollinearity.

The dimensions that are important to account for with our set of hedonic controls include general depreciation, engine power and performance, vehicle size, vehicle safety rating, luxury attributes, and fuel efficiency performance (Espey and Nair, 2005; Bento et al., 2009). We control for general depreciation by including controls for the year the car was built and the current odometer mileage from the NHTS survey. Since all cars in our sample are relatively new, all cars are assumed to be in 'very good' condition as defined by KBB. We control for engine power and performance via horsepower, and car size with cargo space. Our safety measures include an indicator for anti-lock braking system (ABS) and an indicator for side airbags. Our set of controls for luxury features includes indicators for air conditioning, alloy wheels, CD player, and cruise control. We measure fuel efficiency as the highway miles per gallon rating obtained from KBB.

We include indicators to control for unobservables that are common to different vehicle makes (brands), which includes the ability of some auto manufacturers to exert some market power by differentiating their vehicles. Honda and Toyota have well-established reputations for producing reliable cars that may significantly influence demand (e.g., consumer loyalty or general reputational benefits). Further, if there are any Toyota reputational advantages enjoyed by the Prius, including a Toyota brand dummy will control for these effects. We include an indicator for the Toyota Camry to control for any consumer effects that are unique to the Camry for two reasons. Toyota claims the Camry to be the best-selling car in America for 15 out of the last 16 years, and that 90% of Toyota Camrys sold over the last decade are still on the road. No other vehicle has enjoyed such long-lasting attention, which no doubt has led to Camry-specific reputational effects or model loyalty. Second, we find that in our data, the distribution of vehicle prices for the Toyota Camry, particularly the Toyota Camry hybrid, is substantially skewed to the left relative to the overall price distribution in our sample. Preliminary regression results indicate that the Camry has a statistically significant influence on our results, and failure to account for general reputational benefits unique to the Camry leads to a bias in our estimates. Finally, in our national level regressions we include core-based statistical area indicators to control for unobservable regional effects. Indicators specific to all vehicle models and market segments are highly collinear with our existing controls; in other words, any unobservable effects believed to exist within each specific model (not including the Camry) or within a particular market segment is already accounted for via our control variables.

As described above, our key control variable is an indicator for hybrid status, that takes a value of unity for any hybrid, including the Prius, and zero otherwise. This indicator captures any general hybrid effects that may include, but is not restricted to include, demand motives such as altruism, warm-glow, or guilt.

4.4.2. Statistical Summary

Table 1 contains a summary of the data. We report the sample-weighted mean and standard deviation for each of the variables in our

[8] We cannot use MSRP values reported in WARDs, since MSRPs are nationally suggested retail prices and cannot be observation specific. First, our dataset contains fewer than 100 unique make-model-year combinations, which is likely too small a sample to reliably conduct our analysis. Second, restricting our sample to unique make-model-year combinations would render our sample of Prius hybrids to only 8 observations (one for each year in 2002–2009). Finally, restricting our focus to MSRP prices would automatically restrict our hedonic market definition to a single national market.

Table 1
Descriptive statistics.

Variable	Total sample		Toyota Prius		All hybrids	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Price	8161.550	3711.012	13,304.098	2853.924	13,865.525	3782.238
Mileage	47,999.320	35,695.113	34,664.296	28502.431	32,978.520	27,834.708
Year built	2005	–	2007	–	2007	–
Performance						
Highway MPG	30.334	4.188	44.751	0.967	42.961	4.209
Horsepower	154.598	34.838	75.171	2.071	93.005	35.980
Size						
Cargo space	16.646	8.980	15.010	1.167	13.732	2.197
Safety						
ABS	0.428	–	0.998	–	0.987	–
Side airbags	0.322	–	0.484	–	0.643	–
Luxury						
Air conditioner	0.857	–	0.998	–	0.999	–
Alloy wheels	0.187	–	0.998	–	0.865	–
CD player	0.582	–	0.936	–	0.721	–
Cruise control	0.481	–	0.941	–	0.959	–
Make						
Chevrolet	0.120	–	0.000	–	0.000	–
Buick	0.054	–	0.000	–	0.000	–
Nissan	0.070	–	0.000	–	0.007	–
Ford	0.113	–	0.000	–	0.000	–
Honda	0.133	–	0.000	–	0.167	–
Toyota	0.187	–	1.000	–	0.825	–
Model						
Accord	0.067	–	0.000	–	0.024	–
Camry	0.086	–	0.000	–	0.133	–
Civic	0.060	–	0.000	–	0.143	–
Market						
Segment 2	0.310	–	0.000	–	0.143	–
Segment 4	0.097	–	0.000	–	0.000	–
Segment 5	0.413	–	0.862	–	0.761	–
Segment 7	0.083	–	0.000	–	0.000	–
Observations	36167		1222		1847	

1. We report the median year built instead of the mean.
2. We include a summary of make, model, and market indicators for those groups with at least 5% share of observations.
3. Mean and standard deviation summaries are calculated using survey sampling weights.

dataset for the total sample of observations, the sample of Toyota Prius hybrids, and the sample of all hybrids including the Toyota Prius. In total, we have 36,167 observations, and of the 1847 hybrid vehicles, 1222 are Toyota Prius hybrids. Specifically, our group of hybrid vehicles includes the Toyota Prius, Honda Civic hybrid, Honda Accord hybrid, Toyota Camry hybrid, Nissan Altima hybrid, and Saturn Aura.

The average 'very good' price recovered from the Kelly Blue Book for the total sample of observations is $8161.55. The average price for Toyota Prius hybrids is $13,304.10 and the average price of all hybrids is $13,865.52. The all hybrids sample has, on average, a higher price than the Prius hybrids sample because the all hybrids sample includes Toyota Camry hybrids, which relative to all other hybrids in our sample have a substantially higher price and so pull the average price for the group upwards.

Table 1 shows that the average car in our sample has about 47,999 miles, which is higher than the average number of miles on both the Prius hybrids (34,664 miles) and all hybrids (32,979 miles). Hybrids in our sample tend to be slightly newer, have higher highway miles per gallon, and are generally smaller vehicles. Hybrid vehicles also have, on average, more safety and luxury attributes, relative to non-hybrids in our sample. The table shows a wide distribution of vehicles in terms of make, model, and market segment; the most common vehicle makes are Toyota, Honda, Chevrolet and Ford, and the most popular models in our sample are the Toyota Camry and Honda Accord. Toyota represents nearly 82% of the hybrid observations, while Honda makes about 17%.

5. Empirical Results

5.1. National Level Regressions

We first consider regressions using our entire sample defined over a national level market. Each national level regression is specified as the semi-log model in (1), uses the NHTS survey sampling weights, and includes fixed effects for each core-based statistical area.[9] We report regression results in Table 2, and we report in Table 3 the average implied marginal willingness to pay from the regressions reported in Table 2. We note that, in each case, the hedonic control variables generally take their expected sign and are statistically significant.

The first model reported in Table 2 includes only the general hybrid indicator that captures any general demand drivers that are common to all hybrids. We report that the hybrid indicator coefficient is relatively large and statistically significant, indicating that these unobservable hybrid demand drivers account for a relatively large share of vehicle price. As reported in Table 3, the implied marginal willingness to pay for a hybrid is on average $2236, or approximately 16% of the average price for the hybrids in our sample.[10] We find that highway miles per gallon

9 Standard least squares regressions without using survey sampling weights yield qualitatively consistent results.

10 Table 1 shows that the average price for hybrids in our sample is about $13,866, from which we calculate the hybrid premium of $2236 is approximately 2236/13,866 = 0.16 or 16%.

Table 2
Semi-log regression results for national level regressions.

Variable	(1)	(2)	(3)	(4)
Constant	−216.859***	−217.126***	−212.990***	−215.532***
	4.135	4.133	4.139	4.177
Prius	–	0.069***	0.219***	–
	–	0.017	0.020	–
Civic hybrid	–	–	–	−0.140***
	–	–	–	0.017
Hybrid	0.262***	0.229***	–	0.275***
	0.018	0.017	–	0.018
Mileage	−0.000***	−0.000***	−0.000***	−0.000***
	0.000	0.000	0.000	0.000
Year built	0.112***	0.113***	0.110***	0.112***
	0.002	0.002	0.002	0.002
Highway MPG	0.000	−0.000	0.006***	0.002
	0.002	0.002	0.002	0.002
Horsepower	0.003***	0.003***	0.003***	0.003***
	0.000	0.000	0.000	0.000
Cargo space	0.001***	0.001***	0.001***	0.001***
	0.000	0.000	0.000	0.000
ABS	0.051***	0.048***	0.053***	0.048***
	0.007	0.007	0.007	0.007
Side airbags	−0.079***	−0.076***	−0.074***	−0.078***
	0.008	0.008	0.008	0.008
Air conditioner	0.028***	0.030***	0.036***	0.031***
	0.008	0.008	0.009	0.008
Alloy wheels	0.113***	0.109***	0.120***	0.115***
	0.007	0.007	0.007	0.007
CD player	0.028***	0.027***	0.020***	0.027***
	0.006	0.006	0.006	0.006
Cruise control	−0.002	−0.006	0.010	−0.000
	0.008	0.008	0.008	0.008
R^2	0.869	0.869	0.867	0.870

1. Sample size is 36,167 for each regression.
2. Each regression contains indicators for make (reference group is Ford), CBSA effects, and the Toyota Camry.
3. Standard errors are reported below each coefficient.
4. Survey sampling weights were used in estimation of each regression.
5. Statistical significance at the 1, 5, and 10% levels is denoted with ***, ** and *.

is statistically insignificant which indicates that in addition to other behavioral motives such as altruism or warm-glow, the hybrid indicator captures, in part, the attractiveness of more fuel efficient vehicles.

Column 2 in Table 2 adds our Prius indicator, and it is positive and statistically significant. Table 3 reports that the average implied marginal willingness to pay for the Prius is approximately $587. Our general hybrid indicator remains highly significant, but decreases slightly in magnitude with a lower implied marginal willingness to pay of about $1954 or 14% of its average value. The highway miles per gallon variable remains statistically insignificant. These results indicate three important findings. First, a positive and significant Prius coefficient indicates a statistically significant social status signaling value unique to the Toyota Prius (of $587). Hence, this result constitutes formal evidence in support of our primary hypothesis. Second, the continued significance of the hybrid indicator adds credence to our identification strategy in that we continue to find evidence of non-status demand drivers. In other words, results from Model 2 indicate that our finding of a significant hybrid effect in Model 1 was not driven entirely by social status signaling value in the Prius. Third, the Prius effect is relatively smaller than the hybrid effect, indicating that the status signaling effect is smaller than the combined hybrid behavioral effects captured by our hybrid indicator. This makes sense because the demand components captured by the hybrid indicator are more general, while the status value measured by the Prius indicator is considerably more specific. To add a bit more perspective on these estimated values, a $587 Prius premium translates into approximately 4.5% of the average value of a Prius. Further, we note that our estimates are generally consistent with the estimates of Sexton and Sexton (2014), albeit slightly smaller in magnitude.

Table 3
Implied MWTP from the semi-log national level regressions.

Variable	(1)	(2)	(3)	(4)
Prius	–	587	1872	–
Civic hybrid	–	–	–	−1194
Hybrid	2236	1954	–	2350
Mileage	−0.04	−0.04	−0.04	−0.04
Year built	960	961	943	954
Highway MPG	0.17	−2	49	13
Horsepower	27	28	28	28
Cargo space	6	5	7	6
ABS	434	409	450	411
Side airbags	−673	−650	−632	−665
Air conditioner	239	252	310	266
Alloy wheels	963	935	1028	978
CD player	236	234	170	232
Cruise control	−21	−48	84	−4

Models 3 and 4 consider robustness checks relative to our preferred Model 2. In Model 3 we remove the general hybrid indicator, which yields two interesting results: the Prius indicator coefficient greatly increases in magnitude, and highway miles per gallon increases in magnitude and becomes statistically significant. These results have two implications. First, the increase in the Prius coefficient indicates that unobservable hybrid demand drivers (e.g., altruism, warm-glow, or guilt) that were initially captured by the hybrid coefficient are now captured in part by the Prius indicator. Recall that our general hypothesis was that the Prius commands value as a status signal in addition to value from more general hybrid behavioral motives. The increase in the Prius coefficient after removing the hybrid indicator confirms this intuition as the Prius coefficient now captures both the status signaling effect and part of the general hybrid effect. Second, the significance of highway miles per gallon indicates that the Prius is not sufficient to completely capture the demand for higher fuel efficient vehicles. This means that, while Prius consumers are no doubt attracted by higher fuel efficiency, it is apparent that demand for higher fuel efficiency is common to all hybrids and that Prius ownership is driven by factors in addition to fuel efficiency. In general, the differences between Models 2 and 3 confirm our intuition about differences in demand drivers for the Prius and hybrids in general.

Our final national level regression swaps in a Civic hybrid indicator in place of our Prius indicator. The second most widely sold hybrid vehicle is the Honda Civic hybrid, however one main difference between the Civic hybrid and Prius that is relevant to our regressions is that the Civic hybrid is not able to signal environmental consciousness. Moreover, from a statistical perspective, the combination of the Prius and Civic hybrid make up, to a large extent, our general hybrid indicator (about 83% of the hybrid indicator consists of either the Prius or Civic hybrid). For these two reasons, it is only natural to consider the individual effects of Civic hybrid on the price of a car, net of any general hybrid or fuel efficiency effects. As shown in Table 2, the Civic hybrid indicator has a negative and significant coefficient with implied negative marginal value of $1194. This result means that, conditional on unobserved hybrid effects, fuel efficiency, and general mechanical, safety, and luxury attributes, the Honda Civic hybrid is a relatively less expensive car. While surprising at first, this is intuitive. According to U.S. News car rankings and reviews, aside from higher fuel efficiency the Honda Civic hybrid is not generally an attractive vehicle.[11] This means that there is no reason to expect the Civic hybrid to command any price premium that is not driven by general hybrid demand or fuel efficiency. Indeed, removing the fuel efficiency variable from this regression leads to an increase in the estimated coefficient on the Civic hybrid indicator (i.e., the marginal effect moves towards zero), indicating that the unattractiveness of the Civic hybrid is offset by its relatively high fuel efficiency.

In brief summary, the national level regressions reported in Tables 2 and 3 indicate two important findings. First, there is a statistically

[11] This report was accessed online (accessed July 2013) at http://usnews.rankingsandreviews.com/cars-trucks/Honda_Civic-Hybrid/2012/.

significant signaling value of the Toyota Prius of about $587, or 4.5% of the average value of the Prius. Second, there are large and statistically significant demand drivers for hybrids in general, accounting for about 14% of the value of the average hybrid. We believe these effects generally include behavioral motives such as, but not limited to, altruism, warm-glow, or guilt.

6. Additional Regressions and Robustness Checks

6.1. Regressions by Census Division and Core-Based Statistical Area

We next consider smaller market areas, defined as the nine national census divisions and eleven different core-based statistical areas.[12] These regressions allow us to explore the sensitivity of our baseline estimates to alternative definitions of market areas, and to explore potential heterogeneity across markets. In the case of CBSAs, we select all observations located within each CBSA region, and exclude CBSA's with fewer than 20 Prius or 40 general hybrid observations. We exclude survey weights from the CBSA regressions as CBSAs are randomly sampled by the NHTS survey. Results for the Prius and hybrid indicators for the census division regressions are reported in Table 4, and results for the CBSA level regressions are reported in Table 5.

In both cases, we find that our baseline results are generally robust. In the census division regressions, the Prius signaling effect is insignificant only for the East South Central division (in which most hybrid observations come only from Tennessee), and the implied Prius signaling premium ranges significantly across census divisions from $391 to $1012. The hybrid indicator is statistically significant in each census level regression, with the implied marginal willingness to pay ranging from $954 to $2833. In Table 5, the point estimates for both Prius and hybrid indicators match our estimates from previous regressions. The estimates are significant in each CBSA for the hybrid indicator, and for Houston, Los Angeles, San Diego and San Francisco for the Prius indicator.[13] Unfortunately, because of the limited sample size for some CBSAs, we are unable to estimate the Prius signaling value with enough precision to identify a statistically significant effect in all regressions.

Across both of these definitions of market areas, and despite the difficulties in precisely estimating the Prius premium within some CBSAs, we find that our general results are commensurate with our baseline estimates. These regressions also indicate some heterogeneity in the Prius and hybrid values across markets.

6.2. Environmental Status Signal Across Green and Brown Cities

There is much discussion in the literature that the value of the Prius status signal is likely to be larger in relatively greener communities (e.g., Kahn, 2007; Sexton and Sexton, 2014). We follow Sexton and Sexton (2014) and consider four green and four brown cities coming from either Colorado or Washington. Specifically, Sexton and Sexton (2014) define green cities to be cities with a relatively high share of democratic voter support for President Obama in the 2008 election, and relatively brown cities to be those with relatively low democratic voter support for President Obama. This results in two green and two brown cities in each state: in Colorado, green cities are Denver and Boulder, while brown cities are Longmont and Loveland. Green cities in Washington are Seattle and Spokane, while brown cities are Richland and Yakima. To obtain data on each of these cities, we artificially assume that all of our observations belong to households residing in the central business district zip code of each of these cities.[14] We use these zip codes to obtain green and brown city market prices for each of the cars in our dataset from KBB.

From these regressions, we find that our baseline results are robust. Our estimates reveal that the status signal is approximately $650 to $700 across these green and brown cities, and hybrids in general command a premium of approximately $2000. However, there is not a statistically significant difference in Prius signaling value (or hybrid premium) across green and brown communities. This finding is initially unexpected, but it is not without intuition: while it may be true that there is potential for the Prius to command a higher signaling value in relatively greener communities (Sexton and Sexton, 2014), ceteris paribus, this relatively higher signaling value leads to a relatively larger number of Prius hybrids and we would not necessarily expect to find that the equilibrium signaling value of the Prius is higher (or lower) in a relatively greener community. Hence, our results are not at odds with the findings of Sexton and Sexton (2014), and provide important insight into the relative market equilibria of environmental status signals across green and brown communities.

6.3. Alternative Parametric Specifications

We also explore several regressions that are designed to assess the robustness of our model to measurement of vehicle prices, as well as parametric hedonic specification. In particular, we consider semi-log regressions using different measures of vehicle price from KBB — specifically the ‘excellent’, ‘good’, and ‘fair’ price rating — to explore potential depreciation effects on the Prius status signal. Our expectation is that our Prius status signaling estimate does not vary significantly with KBB price measure since we have no reason to believe that the status signaling ability of the Prius depreciates. We also estimate our benchmark regression model both in levels and double logs. We find that, with the exception of the hedonic levels model, for each of these models our baseline hybrid and Prius results are robust. That our results are not robust in the levels model is consistent with hedonic methodological research that emphasizes the restrictiveness of this specification (e.g., Boyle et al., 1999; Parmeter and Pope, 2013).

6.4. Semiparametric Hedonic Regression Specification

Our final regression is designed to incorporate flexibility into our hedonic specification, to ensure that our results are not driven by any statistical modeling assumptions embedded in the semi-log specification. Our main concern is that, while the semi-log specification is more flexible than the benchmark linear model, the imposed linearity and additive separability of the regressors is overly restrictive causing us to inconsistently estimate the Prius status signal. To address this concern, we consider a semiparametric generalization of (1) given by

$$P_i = \beta_0(X_i) + \beta_1 D_{Pi} + \beta_2 D_{Hi} + \epsilon_i. \tag{2}$$

The model in (2) is the partial linear semiparametric regression of, for example, Robinson (1988). In (2), the intercept coefficient is a generalized functional coefficient that takes the hedonic conditioning set as its arguments, while the parameters β_1 and β_2 bear similar interpretation to those given in (1) and are taken to be constants. Notice that in (2) we no longer measure vehicle price in logs, as this transformation is no longer necessary for incorporating flexibility into the model.[15]

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12 The core-based statistical areas include Dallas, Houston, Los Angeles, Miami, New York City, Phoenix, Sacramento, San Diego, San Francisco, San Jose and Washington D. C.

13 The Prius indicators in the Houston and Los Angeles regressions are both significant at the 15% level with p-values 0.14 and 0.12 respectively.

14 Choice of zip code within each city does not influence the results reported in this subsection.

15 A standard nonparametric kernel estimator for (2) is given in Robinson (1988) or Li and Racine (2007), and uses a conditional mean transformation to first recover a consistent estimate of β_1 and β_2, and then a consistent estimate of $\beta_0(X_i)$ in a final step. We use a local constant least squares estimator for all nonparametric estimates, select bandwidths using least squares cross-validation, and use a wild bootstrap based on 399 replications to obtain standard errors of each estimate. See Robinson (1988) and Li and Racine (2007) for further technical details, or Parmeter et al. (2007) for a nonparametric estimator in a hedonic regression context.

Table 4
Semi-log regression results by census division.

Census division	Prius dummy − β_1 Estimate	Standard error	Mean MWTP	Hybrid dummy − β_2 Estimate	Standard error	Mean MWTP	Sample Size	R^2
Pacific	0.092***	0.020	824	0.225***	0.018	2017	5030	0.877
Mountain	0.089**	0.044	767	0.200***	0.038	1718	2082	0.867
W. N. Central	0.116**	0.050	945	0.187***	0.043	1521	1998	0.883
E. N. Central	0.105**	0.052	844	0.257***	0.042	2077	1960	0.881
W. S. Central	0.061**	0.031	530	0.256***	0.024	2234	4994	0.869
E. S. Central	0.011	0.095	93	0.343***	0.076	2833	813	0.887
S. Atlantic	0.046***	0.018	391	0.236***	0.015	2016	13,380	0.866
Mid Atlantic	0.086***	0.030	716	0.226***	0.026	1880	5028	0.874
New England	0.121***	0.058	1012	0.115***	0.064	954	882	0.893

1. Each regression contains a full set of control variables, including indicators for make (relative to Ford) and Toyota Camry.
2. Statistical significance at the 1, 5, and 10% levels is denoted with ***, ** and *.

We choose this specification for the following reasons. First, $\beta_0(X_i)$ is unrestricted in functional form, and as such is a fully general hedonic specification that is immune to functional form misspecification issues that may exist in parametrically specified functions. Second, (2) allows the Prius and Hybrid premia to enter as constant, parallel shifts in the hedonic pricing function. An example illustrates our intuition: consider the negative relationship between odometer reading and vehicle price. This same relationship exists for both Prius and conventional vehicles. Yet, given this relationship, we expect that the price of the Prius is higher than the conventional engine type because of the uniqueness of the Prius as a status signal. Hence, we postulate a parallel shift in the negative relationship between odometer reading and vehicle price on account of the Prius signal that preserves the relationship between odometer reading and vehicle price. We thus extrapolate this intuition into the full hedonic model, allowing for the hedonic pricing function of each vehicle to be fully nonparametric and general via $\beta_0(X_i)$, while allowing for parallel adjustments given the behavioral demand drivers captured by both β_1 and β_2.

Our semiparametric model yields estimates of the Prius status signal of about $951 and the hybrid premium of about $4356. Both of these estimates are statistically significant at a 5% level with standard errors 62.53 and 39.77, respectively. While these estimates are relatively larger than those from our benchmark semi-log parametric estimates, they are consistent with the range of parametric estimates described previously. Hence, while different specifications yield different sized estimates, our general range of estimates is robust, and are not likely driven by functional form misspecification.

7. Discussion

We have presented a series of regressions that have shown a large and significant price premium of hybrids relative to conventional gasoline engine vehicles, as well as a positive and significant price premium unique to the Toyota Prius. Conditional on our hedonic controls, we interpret these estimates to indicate that there are strong demand components for hybrid vehicles that account for approximately 14% of the value of the average hybrid, and that the Toyota Prius has a social status signaling value of approximately $587, or 4.5% of its value. One issue that we have not yet explored is *Prius-specific* demand drivers that (i) are not currently controlled for via the existing control variables in the model, and (ii) may potentially confound our estimate of the Prius status-signal.

7.1. Prius Reputation

The first potential factor we consider is the possibility that the Prius has a reputation of being the most popular and/or dependable hybrid vehicle. Hybrid-electric technology is relatively new, and most hybrid consumers may be first-time hybrid buyers. This potentially increases the uncertainty around the hybrid car-buying decision. A Prius reputation of being the longest hybrid in (generally available) existence, or the general popularity of the Prius among consumers, may reduce this uncertainty, making the Prius a relatively safer investment.

It is possible that consumers perceive Toyota hybrid technology to be superior to alternative brands since Toyota has a generally excellent reputation (also from other non-hybrid vehicles, such as the Camry) and because Toyota has been refining the Prius technology for a longer period of time and in response to higher demand. This effect will be captured by the Toyota brand dummy in all of our regressions. An alternative view is that any reliability reputation earned by the Prius spills over onto all other hybrid-electric vehicles (Heutel and Muehlegger, 2012) as consumers may not be able to differentiate Prius hybrid-electric technology from non-Toyota hybrid-electric technology, or because uncertainty may be generally about battery life and/or the integration of

Table 5
Semi-log regression results by CBSA division.

CBSA	Prius dummy − β_1 Estimate	Standard error	Mean MWTP	Hybrid dummy − β_2 Estimate	Standard error	Mean MWTP	% Prius	Sample size	R^2
Dallas	0.037	0.052	327	0.238***	0.040	2117	2	1448	0.874
Houston	0.112	0.077	1019	0.282***	0.054	2561	2	894	0.864
Los Angeles	0.072	0.046	666	0.250***	0.041	2331	8	1012	0.873
Miami	−0.036	0.068	−330	0.303***	0.052	2770	3	1021	0.862
New York	0.018	0.056	157	0.216***	0.045	1920	2	1270	0.877
Phoenix	0.064	0.059	558	0.201***	0.052	1762	3	1120	0.857
Sacramento	0.084	0.091	729	0.286***	0.066	2498	7	268	0.922
San Diego	0.099***	0.041	882	0.210***	0.037	1864	6	1364	0.876
San Francisco	0.102**	0.051	943	0.166***	0.050	1539	14	527	0.895
San Jose	−0.028	0.076	−266	0.266***	0.073	2543	13	213	0.917
Washington D.C.	0.020	0.065	172	0.218***	0.050	1840	5	592	0.892

1. Each regression contains a full set of control variables, including indicators for make (relative to Ford) and Toyota Camry.
2. We only report results for CBSA divisions with at least 20 Prius observations and 40 all hybrid observations.
3. Statistical significance at the 1, 5, and 10% levels is denoted with ***, ** and *.

a gasoline and electric engine into a single system. Yet, in this case, our Prius status-signaling estimates are not confounded because such general hybrid reputational effects are captured by our general hybrid indicator.

7.2. Marketing Effects

A second potential confounding factor of our Prius status signal is aggressive marketing of the Prius by Toyota. Sexton and Sexton (2014) document Toyota marketing as a potential confounding factor as nearly half of the hybrids sold in the United States in 2010 were Prius hybrids, but that Toyota marketing is not sufficient for explaining the Prius premium.

The potential for Toyota marketing to confound our status-signal estimates is somewhat nuanced. Clearly, aggressive marketing campaigns are effective at increasing consumer awareness of the Prius, which in turn increases demand. Narayanan and Nair (2013) provide empirical evidence of social contagion effects increasing the demand for the Prius. Toyota marketing efforts can have two effects. First, Toyota marketing can increase the generally perceived reliability of the Prius. This effect was discussed in the previous subsection. The second effect is that marketing efforts can increase the popularity of the Prius, which in turn can influence its status signaling value. These latter consequences of Prius marketing, however, are not confounding factors in our status signal estimates. Indeed, Narayanan and Nair (2013) describe social contagion as general peer-referenced consumption, which is not necessarily different from social status signaling. To provide a somewhat exaggerated but nevertheless illustrative example, if Toyota never produced aggressive marketing advertisements for the Prius, it is possible that the Prius would not have become synonymous with hybrid-electric technology, and may not serve as a clear signal of environmental consciousness.

7.3. Prius as a Signal of Wealth

Might the Prius may serve as a signal of wealth, in addition to signaling environmental consciousness? There are two potential types of hybrid consumers who are interested in signaling their wealth: those who care about environmental quality for non-status reasons (e.g., altruism, etc.), and those seeking to display their environmental status. The first type of consumer would be willing to purchase any type of hybrid as long as the vehicle also signals wealth. In terms of environmental preferences, this type of consumer is no different from all non-status seeking hybrid consumers that we control for via our general hybrid indicator. Any wealth or luxury attributes defining wealth signaling cars are accounted for through our hedonic controls.

The second type of consumer — those interested in signaling wealth and environmental status — must purchase the Prius as this is the only way to use vehicle choice to signal environmental status. For this type of consumer, our Prius coefficient is potentially confounded as an estimate of environmental status if there is a strong relation between wealth signaling and environmental preferences, and if we are unable to control for the wealth signaling characteristics of the Prius. First, (Kahn, 2007) shows that there is no correlation between average household income and Green Party share, and that voter support for environmental legislation within census tract increases with Green Party share but decreases with income. Hence, he does not find any evidence that suggests that environmental attitudes are correlated with wealth. Second, our hedonic controls capture a variety of vehicle characteristics that include size, luxury and safety features, and brand effects. Our hedonic specification is designed to account for factors allowing the Prius to serve as a signal of wealth. Therefore, we do not believe that our Prius status signaling estimates are contaminated by Prius demand driven by the desire to signal wealth.

7.4. Preference for Body Style

Finally, we recognize that while the physical uniqueness of the Toyota Prius body-style is the source of its ability to signal status, it is possible the certain consumers simply like (or do not like) this particular body-style, irrespective of the environmentally friendly attributes of the Prius. While such motives would be difficult to disentangle from the environmental status effect in our empirical design, we do not find evidence in popular media to suggest that this is a strong driver of Prius popularity.

8. Concluding Remarks

Recent years have seen a surge in consumer demand for environmentally friendly products, typically purchased at a higher price compared to conventional alternatives. Such demand has piqued the interest of environmental economists, who have adopted behavioral theories such as altruism, egoism, guilt, or social status to explain such behavior. Empirical evidence in support of these motives is, however, scant.

We consider the Toyota Prius as a conspicuous environmental public good, and seek to econometrically measure the signaling value of the Prius. We develop a novel quasi-experimental hedonic model of automobile prices. To the extent that our research design is able to control for unobservable behavioral demand components, we find that the Toyota Prius has a status signaling value to consumers of, on average, \$587. Hybrids, in general, have a premium over non-hybrids of approximately \$1954. These results imply that the status signaling value makes up approximately 4.5% of the value of the Toyota Prius, and the hybrid premium accounts for about 14% of the average price of a hybrid. We explore a variety of robustness checks and find that our baseline results are robust.

Our empirical results have several implications that are relevant to economists and policymakers. First, we provide a robust set of estimates of (i) the status signaling value of the Prius; (ii) the estimate of the marginal value of a hybrid, in general; and (iii) estimates of the relative value of the Prius status signal to a bundle of behavioral demand drivers. Second, our results are qualitatively consistent with the findings of Narayanan and Nair (2013) that suggest that policymakers interested in increasing consumer adoption of hybrid vehicles may want to exploit the status signal as a means of nurturing widespread consumer interest in hybrids, or at least the Prius.

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