

Case study on honda essay

Business



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Papers may be downloaded for personal use only. Consumer Learning and Hybrid Vehicle Adoption Garth Hotel Erich Mueller April 2010 Abstract We study the diffusion of hybrid vehicles among consumers. Using data on sales of 11 different models over seven years, we identify the effect of the penetration rate - total cumulative hybrid sales per capita - on new hybrid purchases.

The penetration rate significantly affects new purchases, and the effect defers by hybrid model. In particular, we find a positive diffusion effect from the Toyota Pries and a negative diffusion effect from the Honda Insight, with elasticity of 0.

23 to 0. 85 for the Pries and -C). 08 to -0. 32 for the Insight. This finding Is consistent with our model of model- specific learning along with anecdotal evidence that early Insight models were perceived to be of lower quality than Pries models.

Higher Insight penetration rates gave a negative signal about hybrid quality and inhibited rather than promoted hybrid adoption. The findings are relevant for policy designed to promote new technologies. JELL codes: QUO, 033, DB Garth Hotel Department of Economics University of North Carolina at Greensboro POP Box 26165 Greensboro, NC 27402[(#)]Due Erich MuellerHarvardKennedy School 79 JEFF Street, Mailbox 25 Cambridge, MA 02142 We thank Polk and JDK Power and Associates for data.

In addition, we thank Jim Sale and seminar participants at UNC, Columbia, and the 2010 ASS meetings for helpful comments and suggestions.

Hybrid electric vehicles are alternatives to conventional, internal combustion engine automobiles that achieve higher fuel economy by combining a conventional engine with a rechargeable battery. The increased fuel economy of hybrids is attractive because of concerns about both climate change and energy security. Transportation accounts for almost one-half of US carbon dioxide emissions, and almost one-half of all petroleum consumed in the US ends up as motor gasoline.

Hybrid cars are capturing an increasing share of the domestic automobile market, rising from 0.4% of all retail sales in May 2004 to 3.6% in July 2009.

As hybrids are a small but growing component of the vehicle fleet, and may be a significant component of a national strategy to deal with climate or energy security, it is important to know what influences consumers' decisions to buy hybrids rather than conventional vehicles. Because hybrids are a newer technology, issues arise that are similar to those involved with the diffusion of all new technologies.

Few studies have examined the determinants of hybrid adoption. This paucity is partly explained by the lack of significant data on this new technology. 1 Gallagher and Mueller (2008) examine the role that state and federal incentives, gas prices, and consumer preferences have on hybrid adoption.

All three had positive effects, but the magnitude was largest for gas prices and consumer preferences. Kahn (2007) uses data from California and finds that environmentalists, as proxies by a community's share of Green Party voters, are more likely to drive hybrids.

On the other hand, many other examples of technological diffusion have been widely studied. For example, Andover (2006) and limit (2005) study the diffusion of cellular phones, and Globes and Kleenex (2002) study the diffusion of home computers. As that final paper emphasizes, learning plays an important role in new technology diffusion. The purpose of this paper is to study the diffusion of hybrid cars among consumers, and in particular to estimate the effects of learning on consumers' decisions to adopt hybrid cars.

We use data on new sales of 11 different hybrid models at the state-quarter level from 2000-2006 and estimate a diffusion model, where the decision to purchase a hybrid is affected by economic incentives, including the price of gasoline and tax incentives for hybrids, as well as the cumulative penetration rate of hybrid vehicles in a particular state. We also present a model of 1 The Consumer Expenditure Survey, for example, contains data on vehicle ownership, but it only first asked respondents the fuel type of the vehicle (gasoline, diesel, or hybrid) in 2005.

The 2006 data set only contains 119 observations of hybrid vehicles, out of more than 56, 000 automobile observations. 3 consumer choice between hybrids and conventional cars, where learning about the quality of hybrids overall or a particular make or model of hybrid affects the agent's decision-

making. This paper relate to two strands of literature: on the diffusion of hybrid cars in particular and on technological diffusion in general.

We add to the small literature on the determinants of hybrid adoption by considering also ten Important Theatres AT uncertainty auto quality Ana learning Tort tens type AT arable good.

This paper also adds to the large literature on technological diffusion by considering the case of uncertainty and heterogeneous quality. Different makes and models of hybrids have varying qualities, and consumers get different signals about hybrid quality from their exposure to different types of vehicles. By taking advantage of the variance in perceived quality across models, we can measure how different signals of quality differentially affect consumer take-up.

The first two hybrid models available to American consumers were the Honda Insight and the Toyota Pries, both first introduced in 2000. The Insight initially dominated the market but was soon overtaken by the Pries, and the Insight eventually was discontinued in 2006.

2 We document and exploit between-state variation in the initial penetration rates of these two models. In states with relatively more Peruses, consumers were more likely to encounter a Pries, and their beliefs on the quality of hybrid cars were impacted by their exposure to the Pries.

We test if the difference between states in the rate of exposure to the Pries and the Insight subsequently affect consumer purchases of hybrids, which we expect if the two models differ in quality and provide signals of hybrid

quality. Our theoretical model describes the intuition behind our empirical results. In a discrete choice framework where consumers are uncertain about the quality of their options, more signals that a particular technology is of high quality lead to a higher probability of choosing that technology.

Alternatively, signals that the technology is low quality reduce the probability.

Signal strength can vary with technology and manufacturer; a signal from one car gives more information about another car from the same manufacturer than it does about a car from a different manufacturer. Thus, more positive signals from a particular technology increase the probability of choosing a same manufacturer's technology more than they increase the probability of choosing another manufacturer's technology. A dynamic extension of the model 2 A substantially redesigned Insight was reintroduced to the American market beginning in the 2010 model year, after our data set concludes. Demonstrates how the signaling effect decays over time; eventually all consumers are sufficiently knowledgeable about all technologies and no longer rely on the signals. Empirically, we find significant diffusion effects for hybrid cars that differ by del.

A higher Pries penetration rate leads to more purchases of all models of hybrids, whereas a higher Insight penetration rate leads to fewer purchases. We estimate that the elasticity of hybrid sales with respect to the market penetration of the Pries in a state is 0.85, whereas the elasticity with respect to the market penetration of the Insight is -0.2 . Our explanation is that the

Insight sends a “ bad” signal about hybrid quality and the Pries sends a “ good” signal.

This is consistent with anecdotal evidence that the Insight was perceived to be of lower quality than the Pries. Articles in the popular press and reviews from Consumer Reports buttress this claim. We also find patterns consistent with consumers’ inference of both model- qua TTY Ana technology-quality; Purls penetration NAS a large positive erect on Pries sales, but also has a positive effect on all other hybrid sales as well.

Insight penetration, on the other hand, has a large negative effect on subsequent sales that seems to be largely specific to the Insight. The discrete choice model that we develop with learning about differentiated technologies demonstrates how signals from different hybrid models can have these differential effects. The first section below summarizes the literature on hybrid cars and technological diffusion.

The second section presents our models of hybrid diffusion. In the third section we describe our data set, and in the fourth section we present our results.

The final section concludes. L. Previous Literature Conventional automobiles are powered by an internal combustion engine (ICE) running on gasoline or diesel fuel. Battery electric vehicles are powered by rechargeable battery packs, but typically have less acceleration performance and limited mileage between charge-ups.

Though electric vehicles have zero emissions, the electricity generated to recharge the batteries is usually produced by burning fossil fuels. Taking this into account, electric vehicles still produce less carbon dioxide (CO₂) emissions per mile.

A hybrid electric vehicle combines the two types of propulsion systems, where the ICE can be used to recharge the battery as well. Furthermore, hybrids can capture some of the energy that is wasted in conventional cars, such as from braking, and use that to recharge, improving their fuel economy even further. Hybrids lack the disadvantage of battery-only electric vehicles of having limited mileage between engine recharges.

Some hybrids can also be made to “plug in,” so that the battery can be recharged either by the ICE or from the electricity from a wall socket.

Plug-in hybrids, though, were not commercially available during our sample period and thus are not represented in our data set. Though hybrids have been produced for more than 100 years, at least since Ferdinand Porsche designed the “Immobilizer” in 1901, they have not been widely commercially available until the late 1990s, when the Toyota Prius and the Honda Insight were introduced. The 2010 model year features 27 hybrid models. The Prius is the most popular model, surpassing one million worldwide cumulative sales in May 2008, and is the most fuel efficient car sold in the US, according to the EPA.

Because of the small market share and the recent introduction of hybrids, few economics papers study these cars specifically. Gallagher and Mueller (2008) examine the effect of federal, state and local incentives on consumer

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hybrid adoption. Using the same data set that we describe here below, they estimate how much of the growth in hybrid adoption is due to these incentives, how much is due to gasoline prices, and how much to preferences for the environmental and energy security. Each of these factors has a significant effect, with preferences and gasoline prices having the largest.

Preferences are proxies for by per-capita Sierra Club membership, quarterly deviation from average temperatures (to measure the salience of climate change) and per capital military participation and war casualties (to measure salience of anti-war sentiment).

Sale (2008) also focuses on tax incentives for hybrid cars but estimates the incidence of those incentives specifically for Toyota sales. He finds that consumers captured a majority of the subsidies, despite the fact that Toyota faced capacity constraints because of excess demand for the Prius during his period of analysis.

The offered explanation is that an increase in retail price would have reduced future demand, and so dynamic considerations led to Toyota declining to capture the subsidies. Kahn (2007) estimates the effect of preferences for environmental quality on hybrid purchases. Using data from California and pronging for environmentalism with a community's share of Green Party voters, he finds that environmentalists are more likely to buy hybrids, as well as use public transit and consume less gasoline.

De Han et al. (2006) use Swiss data on buyers of the Prius to test for evidence of a rebound effect from its purchase. While the most apparent

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rebound effect is probably the 6 decision to drive more miles in a car that is more fuel efficient, they do not test for this effect (since they lack data on miles driven). Rather, they test for two other rebound effects.

First, hybrid buyers could have switched from already fuel-efficient cars to the Pries. Second, average vehicle ownership could increase, if hybrid buyers are using the hybrid in addition to, rather than instead of, another car.

They find no evidence of either rebound effect from a survey of 367 Pries buyers. Lumberman (2009) fits data on aggregate US hybrid sales to two diffusion models: the Bass model and the Geometer model. The Geometer model forecasts higher future growth rates of the hybrid market and is more consistent with industry expectations. 3 The diffusion of a new technology through the economy is an important question and one especially relevant to climate policy.

Not only hybrid cars, but low carbon technologies like carbon capture and storage (CSS) are potentially essential ingredients to an effective policy regime to combat climate change. Though the economics literature is sparse when it comes to hybrid cars, it is fortunately rich with papers that study the diffusion of other technologies. Georges (2000) provides a survey of the literature on technological diffusion, and he focuses on explanations of the dominant stylized fact: the usage of new technologies over time typically follows an S-curve.

Of particular interest in our paper is the effect of learning and externalities on the diffusion of technologies. Manikins (2000) reviews the literature on

social interactions in general, where the actions of some users may affect the actions or outcomes of other users.

Hideous and Melissa (2006) provide a model of technology adoption with cohort and network effects. Peer effects have also recently been studied in the choice of employee retirement plans (Duffel and Ease 2002), health care plans (Sorensen 2006), and medical procedures in developing countries (Kramer and Miguel 2007).

Globes and Kleenex (2002) look for learning and networking effects in the diffusion of a consumer technology, home computers. Using cross-sectional data on 110, 000 households in 1997, they find spillover effects from imputer users: households are more likely to buy home computers in areas where more of their neighbors own computers. This peer effect is larger for heavy computer users and with use of the internet and email, consistent with network effects. A focus of our empirical analysis is heterogeneity in the new technology.

How do different models of hybrid cars differentially affect diffusion among consumers? Models of the Papers Tanat study ten Tousling AT non-nudity automobiles In a salary Tattoos include Lecherous and Reach (2008), Meddled and Soling (2002), and Agreement (1996). 7 diffusion of heterogeneous technologies extend back at least to Jensen (1983), who models a firm's choice among two competing technologies, about which firms are uncertain. In Sense's model, adopting one technology gives the firm information about its quality, which the firm uses to update its prior beliefs about that quality.

Colombo and Mission (1995) and Stonemason and Excavation (1997) also model the adoption decision among a variety of technologies with uncertain payoffs, although learning in these models comes exogenously from the time since which they were introduced. Finally, the diffusion of energy efficient and low carbon technologies is a vitally important question relevant to climate policy. McFarland and Herzog (2006) incorporate technological change, specifically CSS, into an integrated assessment model of climate change.

They use bottom-up engineering estimates of cost functions for various abatement technologies and simulate how different policies would affect diffusion of these technologies in the energy industry. Rose and Josses (1990) also study the diffusion of new technologies in the electricity generation industry. They find that larger firms and investor owned utilities are more likely to adopt new technologies than are smaller or publicly owned firms. II. Model of Diffusion and Learning We present a model of hybrid vehicle adoption that captures inferential learning.

Prospective hybrid vehicle buyers observe vehicles on the road and from their observations update prior beliefs about hybrid quality. We first develop a static model in which the comparative static are easy to derive. We then generalize the model by allowing consumers to dynamically optimize, to investigate diffusion over time. Our model incorporates both “ epidemic” learning effects from Cherishes (1957) and choice among competing technologies as in Jensen (1983). We focus on consumer decisions and disregard other issues, including producer pricing decisions. First consider a static discrete choice model.

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Consumers choose the vehicle with the highest utility, where the utility to consumer i of purchasing vehicle j is given by $U_{ij} = X_j \beta + \eta_{ij} + \epsilon_{ij}$, where X_j is a vector of vehicle attributes, ϵ_{ij} is a mean-zero IID error term with a Type I extreme value distribution, and η_{ij} is the consumer's assessment of the quality of hybrid vehicle j , normalizing the quality of non-hybrid vehicles to zero. The true quality of hybrid j , unobservable to the consumer, is θ_j .

Consumer i receives n_i unbiased, independent signals about vehicle quality, $\{s_{ij}^k\}$. Each signal gives information on one model - if the k th signal is about model j then $s_{ij}^k = \theta_j + v_{ij}^k$, where θ_j is the true quality of vehicle j and $v_{ij}^k \sim N(0, \sigma_j^2)$. These signals can be thought of as observations of actual cars, and so the probability with which the signal provides information about a particular model depends on the market share of the vehicle.

If a model has market share s_j then the probability with which each of the consumer's signals informs his knowledge about model a is s_j .

Consumer i 's assessment of the quality of hybrid j , η_{ij} , is a function of his set of interactions $I_{ij} = \{s_{ij}^k\}$ and it can be generated four different ways. First, if he receives any signals about model j , then his unbiased estimate of θ_j is based on only those signals received about j : this estimate has a mean value of θ_j and a variance of σ_j^2 / n_{ij} . Second, if all of the consumer's signals come from non-hybrid cars, then he gets no additional information on hybrid quality, and his assessment remains at the prior value of $\eta_{ij} = \theta_j$.

Third, he can get an imperfect signal of the quality of J by observing a hybrid vehicle other than vehicle J .

This signal is stronger if the other vehicle is from the same manufacturer as hybrid J than if it is from a different manufacturer. If the consumer does not receive any signals about hybrid J but receives at least one signal about hybrid k made by the same manufacturer as J , then he forms his assessment of n_j based on those signals only along with his prior belief about hybrid quality.

Thus, the mean value of the consumer's belief is μ_j , where α is an exogenous weighting parameter. Fourth, if he receives signals only from hybrids made by a different manufacturer than hybrid J , his assessment's mean value is μ_j' , where $\alpha < 1$ to indicate that he weights these signals less than signals from vehicles made by the same manufacturer. The probability that consumer i purchases vehicle J , conditional on consumer i 's signals I_i , is given by the standard multinomial logit expression: $\frac{\exp(\alpha \mu_j + I_i)}{\sum_k \exp(\alpha \mu_k + I_i)}$.

Supposing that the last equality holds because the signals I_i determine all legalizations of the signals observed only by the individual, one may instead want to know the probability that consumer i purchases vehicle J conditional only on the initial market shares of the vehicles.

Let s be a vector representing the initial market share distribution, and let μ be a vector representing the individual's assessment of quality for all vehicles. Then be a $P(n | s)$ den The function f is the probability density function of the vector conditional on the vector of market shares s .

In general, this integral will not have a closed form solution and must instead be simulated. We impose additional assumptions here to find an analytical solution (these assumptions will be dropped in the dynamic model below). First, we suppose that $\sigma_{12} = 0$ for all models J , so signals contain no noise. Then the must take discrete values, and we can calculate their probability mass function.

Second, assume that the number of signals n equals one. Then, the number of possible signal combinations is just the number of models.

Third, assume that only four car models exist. Model a is a non-hybrid. Model b is a hybrid manufactured by firm Y .

Models c and d are hybrids manufactured by firm Z . Let the initial shares of models be given by a_s , s_b , s_c , and s_d , which determine the probability of any set of signals IQ . Then the probability of purchasing hybrid model c , say, is given by $P_{c|IQ} = (P_{c|I} = a_n) a_s + (P_{c|I} = N. B.) s_b + (P_{c|I} = NC) s_c + (P_{c|I} = ND) s_d$.

We are interested in how this probability changes with the initial distribution of the models.

Since all of the shares must sum to one, we replace a_s with $1 - s_b - s_c - s_d$. Thus, we consider a marginal increase in s_c accompanied by a marginal decrease in a_s and the resulting effect on hybrid purchase probabilities. First consider the effect of this change in the initial distribution on the probability of purchasing model c : $(P_{c|I} = NC) - (P_{c|I} = a_n)$. Evaluating and

simplifying yields
$$d \text{ Pre} = A \{ \exp(\alpha \beta c) - \exp(\alpha \theta) \} \alpha \beta c + \exp(\alpha \theta) [\exp(\alpha \beta c) - \exp(\alpha c + (1 - \theta))]$$

+ $\exp(\alpha \beta c) - \exp(\alpha c + (1 - \theta))$ 10 The constant A is positive.

The entire expression is positive if and only if $\alpha \beta c > \alpha \theta$. When the true quality of hybrid c is higher than the prior belief about hybrid quality, then the probability of purchasing c will increase when more c models initially are present compared to monotony's. Intuitively, an increase in c models relative to non-hybrids gives a higher probability of getting the signal about c compared to getting no signal (from interacting with a non-hybrid owner). If this signal is higher than the prior, then it will increase the probability of buying c.

We also investigate how this increase in the initial share of model c affects the probabilities of purchasing other hybrids. Consider its effect on model d, the other hybrid made by the same manufacturer. The effect is $(\text{Prod law} = \alpha \beta c) - (\text{Prod law} = \alpha \theta)$, which can be simplified to $d \text{ Prod} = B \{ \exp(\alpha \beta c + (1 - \theta)) - \exp(\alpha \theta) \} \alpha \beta c + \exp(\alpha \theta) [\exp(\alpha \beta c + (1 - \theta)) - \exp(\alpha c)] + \exp(\alpha \beta c + (1 - \theta)) - \exp(\alpha c + (1 - \theta))$ where B is a positive constant. The first and third lines are positive whenever $\alpha \beta c > \alpha \theta$, and the second line is negative whenever $\alpha \beta c > \alpha \theta$.

If the true quality of hybrid c exceeds the prior belief about hybrid quality, there are three effects on the propensity to buy hybrid d, each represented by a different line in the expression above.

First, hybrid c gives a positive quality signal about all other hybrids, including d, and thus consumers are more likely to buy d (the “ hybrid signal” effect). Second, hybrid c gives an even stronger positive quality signal about itself, making consumers less likely to buy any vehicle other than c, including d (the “ model signal” effect).

Third, hybrid c gives a stronger positive quality signal about other hybrids of the same manufacturer, d, making consumers more likely to buy d (the “ manufacturer signal” effect). In the expression for $\frac{\partial \text{BRB}}{\partial \text{doc}}$ from the paragraph above, all three of these effects are positive; here the “ model signal” effect is negative. Finally, consider the effect of an increase in the initial share of c on sales of hybrid b, the hybrid made by a different manufacturer than c.

The marginal effect is $\frac{\partial \text{BRB}}{\partial \text{CB}} = C \{ \exp(\alpha \text{c} + (1 - \alpha) \text{O}) - \exp(\alpha \text{O}) \} \alpha \text{d} \text{c} + \exp(\alpha \text{O} + (1 - \alpha) \text{CB}) [\exp(\alpha \text{c} + (1 - \alpha) \text{O}) - \exp(\alpha \text{c})] + \exp(\alpha \text{B} \text{c} + (1 - \alpha) \text{O}) - \exp(\alpha \text{d} + (1 - \alpha) \text{O})] \}$, where C is a positive constant.

The first line of this expression is positive whenever $\text{ICQ} > \text{no}$, and the second and third are negative whenever $\text{ICQ} > \text{no}$. All three lines are analogous to the 1 1 corresponding lines in the previous expression and the effects they represent. However, the sign of the third term (the “ manufacturer signal” effect) is reversed.

Hybrid c gives a weaker signal about hybrid b than it does about hybrid d, and thus the manufacturer signal effect makes consumers less likely to buy hybrids from manufacturers other than the maker of c. Now we explicitly consider the dynamic decisions that consumers face over the purchase of <https://assignbuster.com/case-study-on-honda-essay/>

durable automobiles. We now allow for multiple signals ($n > 1$) with noise ($\sigma > 0$), but we assume that vehicles come in just three models: a non-hybrid model a and two hybrid models, b and c.

In each period, consumers can choose to buy a new car of any model or to hold on to their existing car, which depreciates. Each consumer receives multiple signals per period, based on the share of the various models on the roads, determined endogenously. Further details of the dynamic model, including parameterizations, are presented in the Appendix. Here we discuss simulation results. Figure 1 presents results from four simulations, each with the same parameter values (listed in Appendix Table 1) out Walt Deterrent Minimal Lustrously AT ventricle models Ana ages.

Parameters are chosen so that hybrid b has lower true quality than hybrid c (N.

B.

The next curve, marked with circles and labeled “ binning,” presents simulation results when the initial share of model b is 6%. The curves labeled “ binning” and “ bonito 1” correspond to initial starting shares for model b of 9% and 11%, respectively. In simulations with a higher initial share of model b, consumers are more likely to get a signal of hybrid quality from model b than they are to get a signal from model c. Because the true quality of model b is lower than that of model c, the resultant subjective assessment of quality n is lower in simulations with a higher initial share of model b.

Thus, we would expect that a higher initial share of b leads to lower adoption of both types of hybrids.

This is just what we see in Figure 1, where the simulation with the lowest initial share of model b, 3%, shortly thereafter has the highest hybrid penetration rate. The simulations with higher initial shares of model b, from 6% to 11%, have lower hybrid penetration rates. Note also that this effect is temporary; the hybrid shares converge around period 20 and subsequently bounce around due to the randomness in the simulations.

Eventually, the effect of the initial distribution on consumers' assessments of hybrid quality vanishes, because after enough time has passed most consumers have had the opportunity to accurately assess the quality of both hybrid models. The models formalize some intuition about how heterogeneous quality among a new technology is relevant to its diffusion. An available technology is adopted by consumers not just when they are exposed to it, but when they are convinced that it will increase their utility.

Being exposed to different models of hybrids with varying qualities will lead to different outcomes for future adoption; e. g., being exposed to a low-quality hybrid will make you less likely to buy that hybrid and may make you less likely to buy any hybrid. Furthermore, this spillover signaling effect should be stronger for hybrids from the same manufacturer than for hybrids from different manufacturers, if nonusers believe that hybrid quality is positively correlated among models of a single manufacturer.