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Giving green a second thought: Modeling the value retention of green products in the secondary market

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ABSTRACT

Demand for green products continues to grow. This research examines green products' retention of value and whether new green brands differ from green brand extensions in their ability to retain value amidst technological innovations. Modeling of data from the used car market between 2004 and 2011 shows that hybrid (i.e., green) vehicles lose value faster than their non-hybrid counterparts. However, pure green brands (such as the Prius), whose ability to express greenness is more salient, lose value at a slower rate than green brand extensions. Compared with brand extensions, pure green brands are also less vulnerable to the threat of obsolescence from technological innovations (introduction of fully electric vehicles). Implications for the management and marketing of green product offerings to extract maximum value for firms and consumers are discussed and suggestions for future research are proposed.

1. Introduction

To gain a competitive advantage in the marketplace, firms are increasingly creating green products (Lin & Chang, 2012) or adding environmentally friendly attributes to existing products (Olson, 2013). Since the 1960s, environmental issues have gained prominence in business and public policy discourses. Seventy-two percent of Americans believe it is important to buy green products (Green Brands Global Insights, 2011) and 17% of U.S. adults make decisions driven by personal and planetary health, buying green, healthy, and socially-conscious products, with less price sensitivity (Natural Marketing Institute, 2008). Although willing to protect the environment and to purchase green products (Cleveland, Kalamas, & Laroche, 2005, 2012), consumers remain skeptical of the value that green products provide and have not widely embraced them (Devinney, Auger, & Ekhardt, 2010; Polonsky, Vocino, Grau, Garma, & Ferdous, 2012). Consumer reluctance stems from at least three factors: perceived inferiority of green products (Lin & Chang, 2012, Olson, 2013), unwillingness to incur greater costs (Kahn, 2007), and perceived "greenwashing" on the part of firms (Lin & Chang, 2012). In order for firms to capitalize on favorable attitudes toward the environment, they must therefore offer green products that overcome these obstacles.

One way to assess the value of green products in the marketplace is to investigate their ability to retain value in the secondary market, defined as the market for previously used durable goods (Bayus, 1991). Value retention is important to both consumers and firms because it signals brand equity (Aaker, 1996). In theory, green products should retain greater value than non-green equivalent products because they offer cost savings over time through decreased expenditure on energy or waste (Cronin, Smith, Gleim, Ramirez, & Martinez, 2011; Oliver & Lee, 2010). However, the argument for greater value retention ignores the fact that green technology's rapid evolution makes it more susceptible to cannibalization due to technological improvements.

One important decision for firms introducing green products is whether to launch a new brand or extend an established brand (Aaker & Keller, 1990). Compared with a new brand introduction, brand extensions alleviate risk by leveraging positive brand associations to signal positive expectations (Reddy, Holak, & Bhat, 1994; Sullivan, 1998). In the context of green marketing, brand extensions may allow firms to reduce consumers' apprehension against green technology or performance (Kangun, Carlson, & Grove, 1991; Lin & Chang, 2012; Pujari, Wright, & Peattie, 2003) by associating it with an established brand. The drawback of an extension is that it may, by also bringing to mind the non-green version, limit the green brand's ability to establish itself as a green product. By contrast, a new green brand could become a benchmark for that market, as has the Toyota Prius in the automobile sector.

Using the context of the automobile sector, specifically the used car market, we compare the value retention of green and non-green products and distinguish between new and extension green brands. We examine the rate of obsolescence and product depreciation comparing

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automobile extensions that contain green technology with those that do not. Defined as the relative loss in value due to changes or improvements (Levinthal & Purohit, 1989), obsolescence in our context is captured by the changes between different versions of the same automobile. Our investigation explores whether automobiles with green technology suffer greater depreciation as a result of obsolescence than their non-green alternatives, and if so, why? We first review the nature of green products to advance testable hypotheses and model the value of green products over time, distinguishing between brand extensions and new brand introductions.

It should be noted that the purpose of this study is to inform firms how best to manage their green product offerings so as to increase consumers' perceived value, not to debate the environmental merits of green products. Whether any product can truly be green is a matter of debate, and some have argued that green products may "greenwash" consumers into believing that a product is environmentally friendly when it is not (Delmas & Burbano, 2011). But because the ways in which firms market green products clearly affect consumers' perceptions of certain products as green (Olson, 2013; Pujari et al., 2003), it is worth investigating how characteristics of green products impact the demand and value retention in the marketplace.

2. Literature review: Green products and the secondary market

Green products may aim to reduce waste (e.g., reusable bags), be less harmful to the environment (e.g., dolphin-friendly tuna), and/or reduce consumption of natural resources (e.g., hybrid cars). Our investigation focuses on the latter category, energy-efficient products. Consumers purchase green products for utilitarian reasons (Hartmann & Apaolaza-Ibanez, 2012) as well as for what they mean (Griskevicius, Tybur, & van den Bergh, 2010). The utilitarian benefits refer to the incremental benefits received relative to non-green alternatives, for example savings accrued from energy efficient light bulbs. If the utilitarian benefits do not exceed the benefits from the non-green alternative, the value of green products declines (Olson, 2013). But products also carry meaning and, in this case, green products can convey environmental values (Pagiaslis & Krontalis, 2014). Environmentally conscious consumers may actively search for unique brands that convey their environmental values and express their green attitudes to others through their purchases (Griskevicius et al., 2010).

Prior work on green product purchases is limited because it focused on early adopters or trendsetters, a small portion of the consumer population willing to pay a premium for novelty. These segments differ from the majority of consumers who delay their purchase or purchase older/used versions (Arkesteijn & Oerlemans, 2005; Porter & Sattler, 1999). Yet, for firms to extract optimal revenues from innovations, they must appeal to a wider consumer base than simply innovators and early adopters (Mahajan, Muller, & Bass, 1995): Firms must appeal to consumers who are less inclined to pay a price premium for a new product (Krishnan, Bass, & Jain, 1999).

To address these limitations, this article assesses green products' value retention in the secondary market. Products inevitably lose value in the market of used durable goods because purchasers assume the risk of purchasing a poor quality, already used product (Akerlof, 1970). But the decreased prices in the secondary market allow more consumers to afford the products. The inclusionary nature of the secondary market therefore makes it possible to explore demand for green products from a broad range of consumers.

3. Research context

Our context is the used car market in the Eastern United States[2] from 2004 to 2011. During this time the auto industry sold over 500,000 new hybrid vehicles in the United States (The Automotive News, 2004–2011). Since the oil crisis in the 1970's, the North American automobile industry has spent considerable amounts of resources to produce a viable energy-efficient technology. Though various technologies were proposed and tested, three have garnered mass commercialization: diesel, hybrid, and electric (Gifford, Adams, Corrigan, & Venkatesan, 1999; Pyper, 2012). At the time of writing, hybrid technology is the dominant eco-friendly technology, although it first had to displace diesel technology and is presently threatened by electrical technology (The Automotive News, 2012–13).

The rapid evolution of green technology in the auto industry allows the identification of green attributes that retain the greatest amount of value in the midst of technological change. Hence, although focused on a single industry, the insights into the attributes of green products that consumers value most can apply to a wide range of technological products. For instance, the home improvement industry promotes energy efficiency by arguing that it enhances homes' resale value.

4. Hypotheses development

Our research focuses on the secondary market for automobiles to assess green products' value retention in the marketplace and compare the value retention of green brand extensions versus new green brands. Specifically, our research attempts to answer the following two questions: 1) Do hybrid (green) vehicles retain more value than non-hybrid (non-green) vehicles? and 2) How do green brand extensions and new green brands differ in their value retention in the marketplace? The first question is linked to the broader issue of green vehicles' sustainability in the marketplace by addressing whether secondary market consumers place greater value on green versus non-green products. The second question distinguishes between brand extensions and new brand introductions: both have advantages and disadvantages when developing new products, but prior research does not provide answers as to which may be best for green products. Identifying whether brand extensions or new brands retain greater value presents an important opportunity because value-retaining features can help offset the higher prices caused by green products' energy saving nature and expected long term savings.

4.1. Green products' value retention

If green products are viewed as investments that offer cost savings over time through decreased expenditure on energy or waste (Cronin et al., 2011; Oliver & Lee, 2010), they should retain greater value compared with alternative products that consume more energy. However, the rapid evolution of green technology may instead increase the rate at which green products lose value: New products provide greater value to consumers because their novelty devalues older products by moving them closer to obsolescence (Hausman, 1996).

As technology evolves so too must products and, in the process, firms are compelled to cannibalize their existing offerings (Chandy & Tellis, 1998). The core functions of products often remain constant through evolving technologies; however, the evolution of the technology changes the design and abilities of the product (Chandy & Tellis, 1998). For example, early notebook computers' 3.5 in. floppy disk drives gave way to CD drives and eventually USB ports. Each new improvement pushes the older version further into obsolescence. Cannibalization is especially likely for green products because the technology that allows these products to conserve energy is vulnerable to a loss in market share from newer versions of the product (Chandy & Tellis, 1998) and/or obsolescence through competing technologies (Sood & Tellis, 2005). For example, in the automobile sector, new versions of previously introduced hybrid vehicles that offer better fuel economy and competing technology, such as electric vehicles, could displace the hybrid vehicle as the market leader (van Bree, Verbong, & Kramer, 2010).

From a consumer perspective, reluctance to adopt green products may also harm their value. The well-established cycle of growth

[2] The Eastern Region consists of the following states: Connecticut, Delaware, D.C, Maryland, New Jersey, Pennsylvania, Virginia, & West Virginia.

whereby an innovation is first adopted by a few and then gradually grows until it matures and then declines (Mahajan et al., 1995) applies to green technology. In the introduction and early growth stages, consumers must first gain knowledge about the new product and its perceived benefits, which may result in resistance if it clashes with their existing knowledge structure (Mick & Fournier, 1998; Moreau, Lehmann, & Markman, 2001). Consumers may be reluctant to replace existing technology with a radical innovation (Rindova & Petkova, 2007). Moreau et al. (2001) found that even those considered very knowledgeable about electric technology and cars were reluctant to adopt it because it was incongruent with their current knowledge structure. For instance, even though some full size hybrid vehicles achieve greater gas mileage than smaller combustion engines, consumers may resist updating their belief that the fuel efficiency of a vehicle is largely determined by its size. As consumers gain more knowledge of the technology, the innovation is perceived as less risky, encouraging greater adoption (Ram & Sheth, 1989). However, in markets such as the green market, where emerging technologies are constantly evolving and/or being introduced, consumers may resist updating their knowledge structure regarding hybrid technology, thereby devaluating the product.

The evolution of the green marketplace, including the potential for obsolescence of the technology, indicates that early entrants into the market may lose their value over time. Consumers may not be willing to take on the risk of purchasing a technology that is consistently changing regardless of its intended cost savings. Therefore we propose:

H1. Hybrid vehicles lose greater value over time than equivalent vehicles that do not contain the hybrid technology.

4.2. Green brand extensions versus new green brands

The next hypotheses compare the value retention of new green brands and green brand extensions. Unlike a brand extension, designed to capitalize on existing associations with the parent brand (Reddy et al., 1994), a new brand can create its own identity in the marketplace. Hence, while both green brand extensions and new green brands may perform the utilitarian function of conserving energy, new green brands uniquely stand for greenness. Brand symbolism research (Loken & John, 1993; Solomon, 1983) supports the view that a new green brand would convey greenness more strongly than a brand extension. Although this article does not directly measure consumer motivations for green purchases, it can be argued that the enhanced element of green symbolism conveyed by new green brands is reflected in the value that consumers place on those brands, and can thus be indirectly measured with secondary market product valuation. The fact that a new green brand cannot be confused with a non-green alternative provides value to consumers and this will be represented in reduced depreciation over time. Stated formally,

H2A. Hybrid vehicles that are extensions of a previous brand lose greater value over time than new hybrid vehicle brands.

The comparison between new green brands and green brand extensions can be extended to evaluating the differential impact of technological change on value retention. Extending on H2A, which proposes that new green brands retain greater value than green brand extensions over the years, the next hypothesis (H2B) proposes that green brand extensions are more vulnerable to improvements in technology than new hybrid brands. Specifically, we assess the impact on the value retention of the incumbent green technology of a technological improvement, namely the introduction of an electric car in the market. As discussed earlier, new technologies continue to outdate and displace previous technologies (see Hauser, Tellis, & Griffin, 2006 for a review). "Technological improvements" refer to any technology that contains a level of novelty and provides customers greater need fulfillment than the incumbent technology (Chandy & Tellis, 1998). We focus here on incremental innovations, those containing the lowest level of technological novelty (Chandy & Tellis, 1998), based on the assumption that, if the hypothesized effects are visible for incremental improvements, they will likely hold for innovations that offer consumers even greater value such as market breakthroughs or radical innovations.

The extant literature is unclear as to how technological innovation may differentially impact a stand-alone brand and a brand extension. Because brand extensions can extend the life of a product by leveraging a well-known brand (Reddy et al., 1994), incorporating a green component into existing brands may protect the value from technological cannibalization. However, the value-expressiveness that stand-alone green brands hold over green brand extensions, as captured by H2A, may also make them more resistant to technological cannibalization (Griskevicius et al., 2010). Thus, improvements in technology will push down the value of hybrid extensions (in line with H2A) but the amount of time that passes after the new technology is introduced will compound the loss in value. Stated formally:

H2B. Hybrid vehicles that are extensions of a previous brand lose greater value than stand-alone hybrid vehicle brands after the introduction of an improved technology into the marketplace.

5. Methodology

5.1. Modeling the effect of hybrid technology on the residual value of automobiles in the secondary market

In order to model the effect that hybrid technology has on the value of automobiles we utilize a hedonic price model. Hedonic pricing models are derived from hedonic regression, which is commonly used in economics to estimate value. This model exists when producers and sellers are fully informed about product qualities and prices and when firms can enter or exit the market at minimal cost. Two brands with identical combinations of attributes/product features must charge identical prices (Kalita, Jagpal, & Lehmann, 2004). Hedonic price models have frequently been used in economics research to examine the impact of different house features on housing prices/rents (Ozanne & Malpezzi, 1985; Rosen, 1974) and they have also been used to study the pricing of automobiles (Court, 1939; Sullivan, 1998). The advantage of hedonic price models in the context of used automobile prices is that they permit the examination of the impact of hybrid technology on the value that vehicles retain over time.

We start by introducing the following inverse demand function as presented in Sullivan's (1998) work on twin-automobiles (automobiles that share the same design and production but are branded differently):

$$p = f(Q, Z, B, X) \qquad (1)$$

In Eq. (1), we attempt to predict prices based on certain features of the car and the marketplace. The inverse demand function includes factors that can be used to infer demand. Based on these factors we then use a multiple regression model to predict the value of the vehicle. Price (p) is a vector of the prices of the automobiles in the demand system; Q is a quantity vector; Z includes, for each model/model-year car, a vector of attributes associated with the car; B is a vector of brand factors, including parent-level brand factors and model-level brand factors; and X includes other factors that affect automobile demand, such as the state of the economy. Contained within Z is the hybrid technology that would separate a hybrid vehicle from its purely gas combustion counterpart. Our investigation of automobile features via *Consumer Reports* and Cars.com and interviews of service dealerships indicated that there are no significant differences between the design of each hybrid extension and its gas combustion counterpart. Thus, in terms of design, the existence of hybrid extension vehicles allows us to isolate the value of the hybrid technology through comparison with its alternative.

Brand factors and market level factors are controlled for by comparing hybrid brand extension vehicles with their non-hybrid counterparts. In other words, when comparing brand extension hybrid vehicles to stand-alone hybrid vehicles, the effects of the parent brand reputation are controlled for by comparing within the same brand (e.g., Toyota or Honda). In order to control for model level reputation, we rely on a process developed in prior work to measure reputation in the auto industry (Rhee & Haunschild, 2006).

Prior work in the context of real estate economics has demonstrated that supply side variables can be omitted from the model or held constant (Sullivan, 1998) due to problems with misidentification or measurement (Epple, 1987). Our context is particularly vulnerable to these errors; for example, it is unclear whether a lack of supply for a particular used vehicle would cause consumers to choose another used car model or consider a new car instead. Errors in estimating this likelihood may invalidate the model's ability to link particular demand factors with vehicle value. The nature of the hypotheses further justifies omitting supply side variables. First, we hypothesize that hybrid technology should lower the value of an automobile (H1), even though the supply of used cars containing the hybrid technology is much smaller than the supply of used cars without the technology, a scarcity that, based on traditional economic theory, should instead increase their value. In a similar fashion, sales data from *Ward's Automotive Yearbook* show that stand-alone hybrids outsold hybrid brand extensions during our period of investigation, which again should translate into higher prices for the extensions, not lower as hypothesized in H2A and H2B.

The premise of this research is to examine the value that consumers place on green technology. In order to capture the value of the hybrid technology over time we transform the price of the vehicle into the residual value of the vehicle. The residual value represents the proportion of the original price of the vehicle that buyers in the secondary market are willing to pay after the vehicle was previously owned. As discussed by Sullivan (1998), the market price of a used car reflects the valuation of the marginal buyer and the marginal seller. Sellers must value the price that they will receive from selling the automobile more than keeping the automobile otherwise they would simply hold on to the car. Buyers must value the car more than the market price in order to create a surplus on their part. After trading has occurred, car values often decline due in large part to asymmetry of product quality between the buyer who knows the true quality and the seller who must infer the quality (Akerlof, 1970). Thus, the surplus that buyers enjoy from purchasing the cars dissipates if buyers do not hold on to the existing stock of the car at or above the market price (Sullivan, 1998). The equation below presents the residual value as the price (P) of model m, model year j, the month of sale k, and the year the used model was sold in (time − age), divided by the original sales price.

$$RV = \frac{P_{m,jkt-a}}{P_{m\ jkt}}$$

Our revised equation is as follows:

$$RV = f(Q, Z, B, X) \tag{2}$$

5.2. Sample

The sample consists of eleven models of cars manufactured by five different automakers released June 2004 to September 2011. A full listing of all models and the number of observations in the sample appears in Table 1. The sample omits several models of hybrid vehicles primarily because the sales volume for these vehicles was too low to produce a reliable sales value. Once identified, the hybrid vehicle was paired with its non-hybrid counterpart based on information offered by a representative from each respective automaker. We interviewed the service managers at five major dealerships representing our sample of vehicles (Toyota, Ford, Honda, Mercury, and Nissan) in order to establish comparison vehicles. For example, the Toyota Camry Hybrid was paired with the Toyota Camry SE based on the assessment of the service manager for a large Toyota dealership: of all the various Toyota Camry models, this particular model was determined to be the non-hybrid equivalent to the hybrid model.

Table 1
*Summary statistics by pair.

Vehicle	Hybrid extension?*	Model years	Observations
Ford Escape	Yes	2005–2011	440
Ford Fusion	Yes	2010–2011	42
Honda Civic	Yes	2004–2011	181
Honda Accord	Yes	2005–2007	116
Honda Insight	No	2004–2007, 2010–2011	86
Honda CR-Z	No	2010–2011	28
Mercury Milan**	Yes	2010–2011	38
Nissan Altima	Yes	2007–2011	116
Toyota Highlander	Yes	2006–2011	378
Toyota Camry	Yes	2007–2011	140
Toyota Prius	No	2004–2011	112
Full sample of hybrid extensions			1451
Full sample of stand-alone hybrids			226

* Hybrid extension refers to a situation where a model has a non-hybrid alternative
** The Mercury Milan was discontinued after the 2011 model.

As discussed above, the analysis was conducted at the pair level. Comparing the effects of hybrid technology between two models of the same automobile brand rules out possible confounding effects that may be attributable to parent brand reputation (Sullivan, 1998) or to differences in technology between different automobiles.

5.2.1. Sales price

The sales price of each vehicle was obtained from the NADA *Official Used Car Guide*. The *Guide* publishes the average retail prices based on actual sales of used cars within the eastern region of the United States in the relevant year. The sample includes prices for cars that are from one to eight years of age by 2011, the last year of our sample. Price is missing for vehicles that did not generate enough sales to estimate the price reliably. The main advantage of the NADA used-car prices is that they are based on market transaction and therefore reflect car buyers' actual valuation of the cars (Sullivan, 1998). Based on prices given by the NADA *Guide*, vehicles lose an average of 10% of their value after the first year.

5.3. Explanatory variables

The explanatory variables are measured at both the model and market level when possible. A listing of all variables is provided in Table 2. Model level variables pertain directly to the car model (such as reputation), while market level variables represent the selling environment (such as gas prices). Most of the model and market level variables are contemporaneous with $Priceg_{mjkt}$. This is appropriate because a consumer who purchases a vehicle in year t is most influenced by factors of the model and the marketplace in year t. For example, a consumer who is considering purchasing a 2007 Toyota Camry in month k of year t would be most interested in the gas prices in month k, in year t; as opposed to the gas prices when the vehicle was first sold.

5.3.1. Market level variables

One of the primary selling attributes for green products is the cost savings due to lower levels of energy consumption. Energy prices, as measured by the price of gasoline, have fluctuated considerably over the past years hence increasing the emphasis on energy consumption as a means to reduce costs (Oliver & Lee, 2010). Gas prices for month

Table 2
Definitions.

Measure	Source
$RValue_{gmjkt}$ = The proportion of the original value that remains (the residual value) of vehicle g (non-hybrid is coded as 1, hybrid is coded as 2), model m, model year j, in month k, year t;	NADA *Official Used Car Guide*
$gprice_{kt}$ = average gas price within the sales region during month k, year t	United States Department of Energy
$psold_{kt}\ gmk$ = total number of hybrid vehicles sold during month k, year t, as a proportion of total vehicles sold	*The Automotive News & Ward's Automotive Yearbook*
$sprice_{gmkt}$= price of vehicle g (non-hybrid is coded as 1, hybrid is coded as 2), model m, in month k, year t;	NADA *Official Used Car Guide*
$sprice_{2gmkt}$ = The price of the hybrid vehicle for model m, in month k, year t.	
$hybrid_m$ = dummy variable for model m, 1 if the vehicle contains hybrid technology and 0 if it does not	NADA *Official Used Car Guide*
age_{mt}= age of vehicle at time t, age equals 1 if the model is 2 years of age at year t.	NADA *Official Used Car Guide*
$y_{j,mt}$= model year dummy variables for j = 2004–2011; $y_{04,mt}$ = 1 if the model is from the 2004 model year	NADA *Official Used Car Guide*
$hybridEx_m$= dummy variable, 1 if the hybrid vehicle has a non-hybrid alternative and 0 if it does not	NADA *Official Used Car Guide*
$Adspend_{mkt}$ = amount of advertising expenditure for model m, sold in month k, in year t	Ad$pender™ database
rep_{mt} = reputation for model m in year t	Consumer Reports, JD Power and Associates
$time_{kt}$ = time at month k in year t, after the release of the Chevrolet Volt in December 2010	General Motors Company

k, year *t* within the Eastern United States were obtained from publicly available information provided by the *United States Department of Energy*.

The second market level variable is the number of hybrid vehicles sold within the United States as a proportion of total vehicles sold in month *k*, year *t*: this was used as a proxy for consumer acceptance. We measured the level of acceptance by calculating the total number of hybrid vehicles sold as a proportion of total vehicles sold during the month of interest. The data for total vehicle sales and hybrid vehicle sales was extracted from *The Automotive News* and *Ward's Automotive Yearbook*.

The final market level variable, to identify the impact of newer technology, per H2B, is the time in months since the fully electric *Chevrolet Volt* was first introduced into the North American marketplace (December 2010). The first month (December) was given a value of one and the final month in the sample (September) a value of ten.

5.3.2. Model level variables

Current price of the vehicle is the price that a new model is currently selling for. When assessing the value of the price paid in the used car market it would be reasonable to assume that the previous price paid serves as a reference price for the product. For purchasers of used automobiles the most recent pricing information available to consumers is the price of the most recent model for sale (the price for a new vehicle). We obtained this information from the NADA *Official Used Car Guide* which lists manufacturers' suggested retail price for each model in the present buying period.

The next model level variable is the reputation of the automobile model. Prior work has established the impact of a parent brand on buying behavior (Rhee & Haunschild, 2006) and the impact that model level reputation can have on valuations (Sullivan, 1998). We pursued a similar approach to that developed by Rhee and Haunschild (2006) to calculate the reputation of the vehicle model, using quality ratings in *Consumer Reports* and J.D. Power and Associates publications. A listing of the reputation score for each vehicle is listed in Table 3.

The final model level variable is the advertising expenditure for each vehicle. Following the framework set forth by Sullivan (1998) and using data available from the *Ad$pender* database (2012) we calculated the total advertising expenditure per model for each sales year within the Eastern United States. Total advertising dollars spent toward the promotion of the vehicle by the brand owner, dealerships, or alliances were aggregated from one calendar year at month *k*, year *t*. The total advertising expenditure for a 2008 Toyota Prius that was resold in February 2010 is the aggregate of advertising expenditure from March 2009 to February 2010. Because the sample of used car sales is from the Eastern United States, only advertising expenditures in that region are used.

5.4. Hypotheses testing and estimation

To test the first hypothesis, that hybrid brand extensions lose greater value over time than their non-hybrid alternatives, we conduct a multiple linear regression. Any possible differences between the two types of vehicles are accounted for by a dummy variable coded as 1 for hybrid and 0 for non-hybrid. The first hypothesis focuses only on vehicles that have both a hybrid and a non-hybrid alternative therefore reputation is not included in the initial test. The regression equation is as follows:

$$RV_{gmjkt} = \alpha_o + \alpha_1(gprice_{kt}) + \alpha_2(psold_{kt}) + \alpha_3 \log(sprice)_{gmkt} + \alpha_4(hybrid_m) + \alpha_5(age_{mt}) + \sum_{j=04}^{11} \delta_j\left(y_{j,mt}\right) + \varepsilon_{gmjkt} \tag{3}$$

The results of this test for each pair of vehicles are displayed in Table 4. In support of hypothesis 1, for seven of the eight models investigated, hybrid technology has a significant negative impact on the value retained over time. Hybrid technology did not have a significant impact on the valuation of the Ford Fusion; this may be because the Ford Fusion was only in the secondary market for the last 2 years of our sample and thus may be less impacted by changing technology over the past several years. It should also be noted that the present price of gasoline had a

Table 3
Reputation ratings for vehicles.*

	Honda				Toyota			Ford		Nissan	Mercury
	Accord	Civic	Insight	CR-Z	Camry	Highlander	Prius	Escape	Fusion	Altima	Milan
2011		0.913	0.900	1.000	0.951	0.970	0.936	0.935	0.932	0.966	0.920
2010		0.913	0.920	0.930	0.937	0.937	0.936	0.935	0.932	0.962	0.955
2009		0.913			0.913	0.978	0.936	0.862		0.927	
2008		0.867			0.898	0.977	0.893	0.835		0.915	
2007	0.913	0.867			0.893	0.940	0.883	0.860		0.900	
2006	0.900	0.900	0.880			0.913	0.883	0.851			
2005	0.930	0.935	0.880				0.825	0.820			
2004		0.950	0.860				0.893				

* Reputation was anchored on a scale of 1–0 with 1 representing a perfect reputation.

Table 4
Regression results – hybrid extensions.

Regression results[a] – dependent variable: proportion of original value that remains (residual value)	Ford Escape	Ford Fusion	Honda Accord	Honda Civic	Mercury Milan	Nissan Altima	Toyota Camry	Toyota Highlander
Constant	.433*	0.534	1.468***	0.644*	9.907*	0.688***	−1.958***	0.976***
	(.255)[b]	*(1.590)*	*(0.326)*	*(1.434)*	*(3.931)*	*(0.072)*	*(0.562)*	*(0.222)*
gprice (gas prices)	−.028***	−0.002	−0.044***	−0.074***	−0.017*	−0.001**	−0.095***	−0.037***
	(0.007)	*(0.051)*	*(0.012)*	*(0.022)*	*(0.037)*	*(0.130)*	*(0.014)*	*(0.008)*
Hybrid	−0.047*	0.042	−0.049***	−0.113***	0.322*	−0.107***	−0.095***	−0.070***
	(0.007)	*(0.039)*	*(0.008)*	*(−6.03)*	*(0.117)*	*(−0.013)*	*(0.013)*	*(0.005)*
psold (proportion of hybrids sold)	−4.208*	−8.641	−5.781*	24.153***	−24.979*	−3.775*	−0.292	4.333**
	(1.685)	*(0.413)*	*(3.113)*	*(5.094)*	*(9.104)*	*(−2.214)*	*(3.010)*	*(1.417)*
Age	−0.036*	−0.002	0.005	−0.048***	0.113*	−0.035***	0.011	0.007*
	(0.022)	*(0.052)*	*(0.003)*	*(0.005)*	*(0.044)*	*(−0.018)*	*(0.007)*	*(0.047)*
logSprice (log of sales prices)	0.102*	0.127	−0.149*	−0.003	−2.004*	0.662	0.601***	−0.021
	(0.046)	*(0.359)*	*(0.07)*	*(0.329)*	*(0.879)*	*(0.33)*	*(0.129)*	*(0.047)*
y11	0.029*	0.008		0.118***	0.019	−0.156*	0.247***	0.185***
	(0.138)	*(0.13)*		*(0.033)*	*(0.045)*	*(−2.62)*	*(0.023)*	*(0.013)*
y10	0.257*	0.011		0.068***	0.002	−0.118*	0.187***	0.101***
	(0.117)	*(0.75)*		*(0.019)*	*(0.09)*	*(−2.91)*	*(0.023)*	*(0.008)*
y09	0.234*			0.057***		−0.074*	0.125***	0.022**
	(0.092)			*(0.020)*		*(−2.78)*	*(0.019)*	*(0.008)*
y08	0.232**			0.012		0.032	0.074***	−0.059***
	(0.069)			*(0.019)*		*(1.43)*	*(0.016)*	*(0.008)*
y07	0.098*		−0.007	−0.0348		−0.009	0.051**	−0.211***
	(0.047)		*(−0.76)*	*(0.021)*		*(−0.30)*	*(0.015)*	*(0.009)*
y06	0.027		0.004	−0.001				−0.296***
	(0.025)		*(0.77)*	*(0.022)*				*(0.012)*
y05	−0.167*		−0.087	−0.064**				
	(−0.230)		*(0.008)*	*(0.022)*				
y04				−0.052				
				(0.046)				
Observations	440	42	116	181	38	116	140	378
Shapiro–Wilk test	0.953	0.968	0.980	0.961	0.951	0.936	0.838	0.974
F	379.78	1.67	104.49	30.90	3.16	32.52	31.68	414.99
Adjusted R^2	0.941	0.357	0.871	0.710	0.467	0.734	0.668	0.962

[a] Significant at the 5%(*), 1%(**), and 0.1%(***) level of significance, two-tailed test.
[b] Standard errors are in parentheses.

significant negative impact (possible interactions between hybrid and gas prices were examined and found to be non-significant), but this may be explained by the dynamics between the primary and the secondary market, as discussed earlier: because the market for vehicles includes both new and used products, higher gas prices may drive consumers to invest in newer vehicles with even greater fuel efficiency (Porter & Sattler, 1999). In other words, in this market, concern with gas prices may increase demand in the primary market, hence reducing that in the secondary market.

The second hypothesis proposes that stand-alone hybrid vehicles, that is those without a non-hybrid alternative, retain more value over time than brand extension hybrid vehicles. This hypothesis was tested with multiple linear regression using the same variables as those in Eq. (2) above with three exceptions. We replaced the dummy variable "hybrid" with a dummy variable that differentiates between hybrid extension vehicles (coded as 1) and stand-alone hybrid vehicles (coded as 0). We also included a measure of model reputation to account for perceived differences between models under the same parent brand. The regression equation is:

$$\begin{aligned} RV_{gmjkt} = {} & \alpha_o + \alpha_1(gprice_{kt}) + \alpha_2(psold_{mkt}) + \alpha_3 \log(sprice)_{mkt} \\ & + \alpha_4(hybrid_m) + \alpha_4(age_{mt}) + \alpha_5 \log(Adspend)_{mkt} \\ & + \alpha_6(rep_{mt}) + \sum_{j=04}^{11} \delta_j \left(y_{j,mt}\right) + \varepsilon_{gmjkt} \end{aligned} \tag{4}$$

The results appear in Table 5. In support of H2A and H2B, hybrid extensions have a negative impact on the residual value of the vehicle. In other words, stand-alone hybrid vehicles retain a greater proportion of their value over time than brand extension hybrid vehicles.

In order to test hypothesis 2B, we conducted a longitudinal analysis to explore the impact on hybrid vehicles' valuation of the introduction of the fully electric *Chevrolet Volt*, an incremental technological innovation compared to the hybrid. The Volt is an improved technology simply because its fuel mileage is twice as good as hybrid vehicles' (51 mpg for the *Prius*, 101 mpg for the *Volt*). Hypothesis 2B predicts that the introduction of technologically improved green products would significantly impact the hybrids' valuations and that hybrid brand extensions (e.g., the Honda Civic) would lose value faster than stand-alone hybrid brands. The formalized model is outlined in Eq. (5) below. We designated both the time since the *Volt* was first introduced and brand reputation as random effects within the model. In line with previous work (Wanberg, Zhu, Kanfer, & Zhang, 2012), the time variable was designated as a random effect so as to explore differences over time between units in our analysis. The brand's reputation was also included as a random effect given that, in the automobile market, a brand's positive reputation is known to disproportionately impact consumer demand (Rhee & Haunschild, 2006). The remaining variables were included in the fixed effects model illustrated below. For the sake of simplicity, parameter estimates (β_{mijkt}) for model (i), model year (j), sold in month (k), of year (t) were condensed to β_v.

$$RValue_{mv} = \beta_{0v} + \beta_{1v}(time_{kt}) + \beta_{0v}(rep_{mt}) + \varepsilon_{mv} \tag{5}$$

$$\begin{aligned} \beta_{0v} = {} & \gamma_{00} + \gamma_{01}(age_{mt}) + \gamma_{02}(hybrid_m) + \gamma_{03}(hybridEx_m) \\ & + \gamma_{04} \log(Adspend)_{(Volt)kt} + \gamma_{05} \log(Adspend)_{mkt} + \gamma_{06}(rep_{mt}) \\ & + \gamma_{07} \log(Sprice)_{mkt} + \varepsilon_{mv} \end{aligned} \tag{6}$$

$$\beta_{1v} = \gamma_{10} + \gamma_{11}(hybridEx_m) + \varepsilon_{mv} \tag{7}$$

$$\beta_{2v} = \gamma_{20} + \varepsilon_{mv} \tag{8}$$

Table 5
Regression results – hybrid extensions vs. stand-alone hybrids.

Regression results[a] (hybrid extensions and non)[b] – dependent variable: proportion of original value that remains (residual value)

	Toyota	Honda		Toyota	Honda
Constant	0.421**	0.983***	y11	−0.084***	0.188***
	(0.156)[c]	(0.163)		(0.025)	(0.021)
Extension	−0.117***	−0.081***	y10	−0.023*	0.114***
	(0.009)	(0.023)		(0.013)	(0.016)
Hybrid	−0.084***	−0.097***	y09	−0.019*	0.079***
	(0.006)	(0.012)		(0.008)	(0.019)
psold (proportion of hybrids sold)	−5.563**	23.973***	y08	0.008	0.054**
	(1.722)	(3.972)		(0.011)	(0.019)
gprice (gas prices)	−0.039***	−0.058***	y07	−0.033	−0.093***
	(0.009)	(−0.058)		(0.018)	(0.013)
logSprice (log of sales prices)	0.268*	−0.853***	y06	−0.056	−0.070***
	(0.031)	(0.120)		(0.027)	(0.012)
Age	−0.089***	−0.046***	y05	−0.009	−0.094***
	(0.009)	(0.004)		(0.040)	(0.013)
LogAdspend (log of adspending)	−0.009	0.002	y04	−0.131	0.112**
	−0.005	(0.007)		(0.116)	(0.035)
Reputation	−0.04	−0.405**	Observations	Camry 140, Prius 112, Highlander 378	Accord 116, Civic 181, Insight 86, CR-Z 28
	(0.071)	(0.123)			
			Shapiro–Wilk test	0.955	0.991
			F	204.28	90.36
			Adjusted R^2	0.867	0.779

[a] Significant at the 5%(*), 1%(**), and 0.1%(***) level of significance, two-tailed test.
[b] Hybrid extension refers to those vehicles which have a non-hybrid counterpart, vehicles considered as non-hybrid extensions are the Honda Insight, the Honda CR-Z and the Toyota Prius.
[c] Standard errors are in parentheses.

The full results are displayed in Table 6. In line with Hypothesis 2B, the longitudinal analysis reveals that, in the 10 months following the release of the *Volt*, the value of hybrid extension vehicles declined at a faster rate the longer the *Volt* was in the marketplace (Table 6).

6. Discussion

The marketplace for green products continues to grow as energy prices rise and attitudes toward environmental issues and green consumerism change. Firms have attempted to capitalize on this growing market by either introducing uniquely new brands or extending existing brands. This research identifies previously unexplored dynamics within the market for green products, and the secondary market more general. The differential value retention of new green brands and green brand extensions suggests that their dual utilitarian (i.e., cost savings) and value-expressive (i.e., greenness) functions affect their perceived value in the market. The difference in value retention rates between stand-alone hybrids and hybrid extensions offers initial empirical evidence that the degree to which a brand is uniquely symbolic of greenness is beneficial to its value retention. Furthermore, the continuing evolution of the marketplace for green products, with the regular introduction of improved technologies, accentuates this effect. Specifically, the introduction of the fully electric vehicle accelerated the value that hybrid extension vehicles lost but this value loss was lesser for stand-alone green brands than for green brand extensions.

This research informs marketers and researchers alike how best to manage green product offerings so as to extract maximum value for companies and consumers. Firms may invest millions of dollars in the production of green technology only to never realize the benefits simply because they were unable to generate enough demand for their

Table 6
Longitudinal analysis – the impact of new technology on the valuation of prior technology.

Mixed model results[a] – dependent variable: proportion of original value that remains (residual value)

	Model 1: Mixed model (no random effect variables)		Model 2: Random effect (time)		Model 3: Random effect (time and reputation)	
Fixed effects	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	−0.279	0.660	−0.510	0.498	−0.6881	0.5059
Age	−0.054***	0.0016	−0.060	0.003	−0.08237*	0.0016
Hybrid	−0.080*	0.003	−0.062*	0.029	−0.0667*	0.0212
hybridEx	−0.271***	0.053	−0.163***	0.036	−0.1034*	0.0272
Log(Adspend)	0.024***	0.0039	0.028***	0.006	−0.0005	0.0041
Log(Adspend_Volt)	−0.032**	0.010	−0.039***	0.010	0.0701	0.0958
rep (reputation of vehicle)	0.123	0.106	0.084	0.104	−0.1692	0.1049
Log(sprice)	0.4003***	0.0742	0.365**	0.115	0.3893*	0.0709
Time	−0.016***	0.003	−0.001	0.009	0.0056	0.0073
hybridEX x time			−0.020**	0.0069	−0.0098**	0.0044
Random effects						
Intercept	0.012***	0.003	0.003*	0.001	0.369*	0.211
Slope			0.0001*	0.000	0.0001*	0.000
Random effects						
Intercept					−0.378*	0.218
Slope					0.391*	0.237
Residual	0.011***	0.000	0.010***	0.000	0.009***	0.000
Cohen's effect size measure, f^2			*0.289*		*0.425*	

[a] Significant at the 5%(*), 1%(**), and 0.1%(***) level of significance, two-tailed test.

products as in the case of General Motors' foray into alternative fuel systems long before Toyota's (German, 2004). The finding that hybrid extensions lose greater value over time than their non-hybrid alternatives is in line with previous literature on product innovation which argues that, as technology improves, prior versions become less valuable (Sood & Tellis, 2005). But the findings also highlight important moderators of the loss in value by revealing differences between pure green brands and green brand extensions and shedding light into the valuation of utilitarian versus value-expressive components.

Our primary findings that stand-alone green products retain greater value than extensions of non-green products suggest that firms should emphasize the greenness of their products wherever possible. Some products, such as reusable water bottles or bags, or even the market of ecological tourism are visible to others and hence readily signal the bearers' green values (Erdem & Swait, 1998). But even green products that are less visible, such as cleaning products and soaps touted as environmentally friendly, can retain greater value if they are not confused with their non-green alternatives.

The second finding, that technological change decreases green products' value retention, concerns the staying power of green products. Some critics argue that green consumerism is a fad and does not provide the firm with any long-term advantages (Delmas & Burbano, 2011, Devinney et al., 2010). Collectively our findings show that, while this argument is indeed valid given the risks of technological change in the green marketplace, not all green brands suffer to the same degree. Consumers who make an investment in green technology incur a significant risk. The finding that rapid changes in technology lead to cannibalization of older versions of the technology is particularly important for green technology because green products are often marketed as investments that provide greater value over time.

We infer that a brand's symbolism impacts value retention in the secondary market and this suggests that characteristics of a product may affect whether it retains or even gains value as a function of its history in the market. The findings from this investigation based on sales data complement previous ethnographic research insights regarding the sociocultural embeddedness of "alternative market systems," such as flea markets or swap meets (Sherry, 1990, p. 13). Hence, more generally, the research contributes to a currently small body of research on value dynamics within the secondary market (Bayus, 1991; Desai & Purohit, 1998).

7. Limitations and future research avenues

Notwithstanding support for the proposed dynamics of value retention of green products, the research is limited given the used automobile context and the reliance on industry data. Albeit an ideal context to explore differing valuations for extension versus stand-alone products, the automobile industry is only one context and the findings may not generalize to other industries and product categories. The reliance on used automobiles made it impossible to incorporate supply side information in the model and isolate supply side shocks on the vehicles' value. Testing the proposed dynamics of product value retention in markets that allow the inclusion of supply side variables would address these limitations.

Another limitation lies in the use of market data for assessing value and not consumer perceptions of the products. Consumer motivations for purchasing the products can only be inferred from the amount they are willing to spend on the green products in the secondary market. Future research should supplement the findings on the value retention of pure green brands compared to extension brands with consumer data where their ability to express their environmental values through their purchases would be measured directly. Notwithstanding these limitations, the findings offer a strong base upon which to further research the dynamics of green products' value retention in the secondary market.

8. Conclusion

This investigation into green products' value retention in the secondary automobile market highlights novel dynamics on the interplay between product design, green attributes, and value retention. It is not simply enough to offer consumers a green product alternative but where possible firms should attempt to maximize consumers' ability to use the product to signal their greenness. The notion that certain green products can be valued higher than non-green alternatives has implications into both product design and marketing.

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