It`s not easy being green: the effects of attribute tradeoffs on green product preference and choice

Eric L. Olson
BI Norwegian Business School

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Erik L. Olson
Professor of Marketing
BI Norwegian Business School
Nydalsveien 37
0484 Oslo, Norway

telephone: +47 46410554
e-mail: erik.olson @ bi.no

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Abstract

Despite widespread pro-green attitudes, consumers frequently purchase non-green alternatives. One possible explanation for this value–action gap is the tradeoffs that green products often force on their users: higher prices, lower quality, and/or reduced performance. The current study uses conjoint analysis to uncover the attribute preferences of car and TV buyers when green attributes are negatively correlated with conventional attributes. These attribute preferences are then used to predict choice among sets of green and less green alternatives currently sold in the marketplace. Strong preferences for green products are found when tradeoffs are not apparent, but preference shifts significantly to less green compromise alternatives when the actual attribute tradeoffs are considered. Although general preference is reduced by tradeoffs, a green product that offer some compensatory advantage on a conventional attribute does attract a broader spectrum of consumers, while only "dark green" consumers are willing to pay the price to go green when the product offers few compensatory qualities. In all cases, however, predicted buyers of the greenest technologies offset some of their environmental benefits by choosing more energy-thirsty specifications on negatively correlated conventional attributes. Managerial and public policy implications of the findings are then discussed.

I can't buy a toilet that works. It will cost us thousands of dollars to go back and add some kind of jet stream to the toilets. You flush them 10 times and they don't work.

U.S. Senator Rand Paul, March 10, 2011, Senate Committee Hearing commenting on water-saving toilets

Compact fluorescent light bulbs are more expensive, contain hazardous mercury, and recently The Wall Street Journal reported that their promised longevity is exaggerated by almost 33%. Then there are consumer complaints that they emit a light that is annoying and in severe cases even gives them headaches.

U.S. Congressman Joe Barton, January 11, 2011, USA Today editorial regarding the forced adoption of CFL bulbs due to the ban on incandescent light bulbs

The recent Journal of the Academy of Marketing Science special issue on sustainability (February 2011) highlights marketing's growing role in protecting and preserving the environment, in part through the development and promotion of green products (Huang and Rust 2011; Hult 2011). As the quotes above illustrate, however, it often isn't easy being green. Environmentally friendly products can force consumers to make tradeoffs on other important attributes such as price, quality, and performance compared to "browner" alternatives. These attribute tradeoffs may also explain the value–action gap between the pro-green attitudes of most consumers and their much rarer pro-green behaviors (Bamberg 2003; Barr 2006; Rokka and Uusitalo 2008). From an environmental perspective, this gap between attitude and behavior also means that green products are not likely to successfully displace brown alternatives and hence have a significant positive impact on the environment (Barr, 2006; Kollmuss and Agyeman, 2002; Pujari et al. 2003; Pujari 2006).

Surprisingly little empirical research has addressed the impact of attribute tradeoffs as an explanation for the often disappointing levels of green product adoption by consumers, but such understanding is vital if green products are to achieve mass-market status (Peattie 1999; Rokka and Uusitalo 2008; Young et. al. 2010). The purpose of this article is to predict the attitudinal and behavioral influence of green attribute tradeoffs involving two major environment-impacting product categories that offer differing tradeoff contrasts: (1) cars and (2) TVs. Preferences for

green technology hybrid cars, which offer no advantages on non-green attributes versus gasoline equivalents, are contrasted with preferences for LED TVs, which offer advantages in picture quality in addition to green benefits versus LCD and plasma screen equivalents. Using a conjoint analysis model involving negatively correlated attributes, the study finds high preference for the greenest alternatives in isolation, but predictions for green behavior drop dramatically when the tradeoffs are considered. This reduction in preference, however, is much less severe for green LED TVs that offer a compensatory advantage on a conventional attribute. An analysis of individual respondents also reveals that hybrid car buyers have a much greener profile than do diesel or gasoline buyers, while LED TVs attract a broader spectrum of buyers who do not have a greener profile than buyers of less green TV technologies. Predicted buyers of the greenest technologies in both categories share a preference for more energy-thirsty specifications on negatively correlated conventional attributes, however, which offsets some of their choice's environmental benefits and provides support for the presence of product specification rebound effects. Implications for these findings are then discussed.

Background

Opinion polls around the world consistently find large majorities of citizens expressing strong support for environmental issues (Leiserowitz et al. 2006; Nisbett and Myers 2007). Despite their environmental concerns, however, consumer preferences for energy consuming products, such as cars and TVs, frequently favor versions with larger dimensions and/or capabilities that increase their raw material and energy consumption. For example, compared to the mid-1970s, the average car sold in the U.S. is now 33% faster in reaching 60 mph (Seaman 2011). During this same time period the average weight and horsepower of American cars increased 20% and 100% respectively, while in Europe the best selling VW Golf grew 57% heavier and 125% more powerful (Csere 2006). Between 2004 and 2007, the median TV screen size went from 34 to 46 inches, and the corresponding increase in electricity consumption prompted California to legislate TV energy efficiency standards to avoid the costs of building additional power plants (Farhi 2009; Walkeron 2008). Consumer preferences for high specification cars and electronics have also largely negated the substantial efficiency improvements in their designs during recent decades (Davis 2008). The U.S. is the global leader in per capita energy use, and sustainability experts worry that consumption in the rest of the world is following a similar growth pattern, as China is currently the world's biggest car market and the largest greenhouse gas emitter (Buckley 2010; Lewis 2010).

In contrast to the mass market, only the small "dark green" consumer segment consistently follows through on their pro-green attitudes by performing pro-green behaviors (Connolly and Prothero 2003; Ginsberg and Bloom 2004; Peattie and Peattie 2009). Thus an important goal for environmental activists is to eliminate the value–action gap and widely expand the proportion of dark green consumers. Suggestions include making green attributes more visible and important to consumers in marketing programs by linking them more clearly to reduced environmental degradation, and/or by associating the high prices and low sales of green products with positive attributes such as status and exclusivity (Burroughs 2010; Kilbourne and Carlson 2008; Sheth et al. 2011). But these approaches imply that deficits in green behavior result from poor marketing and/or consumer irrationality regarding green alternatives, rather than a logical consumer response to known tradeoffs.

Green attribute tradeoffs

Roger's innovation diffusion theory predicts that innovations that offer greater advantages versus current products will typically experience faster and more widespread adoption (Rogers 1995). While this prediction has been confirmed in numerous studies (Janssen and Jager 2002), the theory does not consider choice sets featuring negatively correlated attributes, such as those illustrated by the opening quotes, where the green-advantaged products are compromised on other conventional attributes. Given the widespread public interest in protecting the environment, green-advantaged products that are also superior to brown products on most conventional attributes, such as price, quality, and performance, are likely to be chosen by nearly all buyers. Thus to understand why average consumers frequently choose brown alternatives, it is important to determine the influence of tradeoffs involving green attributes (Peattie 1999).

Although some research has explored the relationship between green and conventional product attributes, virtually no empirical study has explicitly examined the impact of negative attribute correlations on green product consideration (Young et. al. 2010). Research in other fields, however, finds a breakdown in the predictive accuracy of multi-attribute models when choice sets contain negative attribute correlations, because in such cases it is impossible for the consumer to "have it all" (Newman 1977; Olson and Widing 2002). Under these conditions, consumers may choose a compromise alternative with lower total utility to avoid their highest utility option's unattractive value on a negatively correlated attribute (Simonson 1993; Widing and Talarzyk 1993). Anecdotal support of this desire to avoid the poor attribute scores that the greenest alternatives commonly force on buyers has been found even among dark green consumers (Young et al. 2010). Thus it is expected that average consumers are likely to prefer green alternatives when tradeoffs are not considered but choose a less green "compromise" product when tradeoffs are acknowledged in order to avoid low values on negatively correlated conventional attribute(s):

H1: Preferences for the greenest attribute levels and products will be highest when tradeoffs with other important attributes are not explicitly considered but will shift to browner alternatives when the tradeoffs are acknowledged.

To move adoption beyond the dark green segment, a green product is likely to need advantages on conventional attributes in comparison with brown alternatives to compensate for its other disadvantages (Pujari et al. 2003; Pujari 2006). For many green products, one such compensatory advantage is lower operating costs due to reductions in energy consumption. Since the vast majority of energy used to power home appliances and cars around the world is directly or indirectly sourced from carbon-based fuels, lower energy use not only slows the depletion of natural resources but is also responsible for reductions in greenhouse gas emissions. Thus energy use is likely to be both a green attribute and operating cost attribute when evaluating various product alternatives.

The decision difficulties that result from negative correlations between green and conventional attributes can frequently be attributed to the two strategies typically employed by manufacturers to reduce the energy use and emissions of their products. The first strategy is based on the adoption of energy saving technologies that typically trade off energy savings with a higher purchase price. For example, hybrid cars, such as the Toyota Prius, combine sophisticated batteries and electric motors with a gasoline engine to achieve substantially higher fuel economy and lower CO_2 emissions than conventional gasoline equivalents, but the added cost, weight, and space requirements of these extra components also bring higher prices, reduced driving pleasure, and less interior space (Olson 2012). The second strategy to providing energy savings is through reductions in the quality and/or quantity of other attribute values such as convenience, size, or performance. For example, TVs with smaller screens and lower resolution will tend to use less energy than larger higher definition screen alternatives.

One difference between the green car and TV examples, however, is that only LED TVs provide an advantage on a conventional attribute besides energy use, because they also provide a superior picture that at least partly compensates for the higher price of the technology (Carnoy and Katzmaier 2010). In contrast, the typical hybrid car offers no consumer advantage versus equivalent gasoline cars besides better fuel economy and lower emissions (Olson 2012). Thus, consumers might choose LED TVs for non-environmental reasons, while the same cannot be predicted for hybrid cars. This key difference between the greenest TV and car technologies leads to the following hypotheses:

H2: Green technologies that provide more advantages versus browner alternatives on non-green attributes, such as LED TVs, will be chosen more frequently than will green technologies that offer few advantages on non-green attributes, such as hybrid cars.

H3: When the greenest technology offers few advantages versus browner alternatives on non-green attributes, as is the case with hybrid cars, it will be chosen mostly by dark green consumers.

H4: When the greenest technology offers important advantages versus browner alternatives on non-green attributes, as is the case with LED TVs, it will be chosen by non-green consumers.

Of course choosing an energy saving green product does not automatically mean lower energy use and emissions, as cost savings from higher efficiency can lead to more frequent product use and/or purchases (Davis 2008). For example, a recent study found the higher fuel economy enjoyed by hybrid car owners led to 20% more annual driving miles that offset a large portion of the reduced CO_2 emissions (Halvorson 2009). This efficiency-inspired increase in consumption is known as rebound effect or Jevon’s Law, named after the nineteenth century economist who observed an increase in coal consumption with the introduction of more efficient steam engines. While many advocates of high efficiency products ignore or dismiss rebound effects as insignificant, their existence has been confirmed in many empirical studies (Sorrell 2009; Tierney 2011). One dimension of rebound effects that has received scant attention, however, is related to product specification upgrades on the negatively correlated attributes. For example, consumers who choose a fuel saving hybrid car may feel the efficiency gains allow them to afford more powerful but also thirstier engines that offset some of the technology-related fuel economy gains. Similarly, someone choosing an energy efficient LED TV might also feel inclined to "spend" some of the energy savings on an energy consuming larger screen. Thus it is expected that those choosing the greenest technologies will also show stronger relative interest in attributes and attribute levels that are negatively correlated with energy efficiency, leading to the following hypothesis related to product specification rebound effects:

H5: Green technology buyers will demonstrate more interest in the higher energy consuming levels of attributes negatively correlated with energy use.

Method

The study was conducted in Norway, a country with a reputation for high environmental concern amongst its citizens, ranking fifth greenest out of 163 countries in the 2010 Environmental Performance Index (EPI 2010). Data were collected with an online questionnaire sent to randomly drawn customers and/or members of Norwegian organizations representing the non-profit, financial, manufacturing, and education sectors. Screening eliminated 57% of the invited participants because they had not recently purchased or were not currently considering the purchase of a car or TV. The remaining 68 car and 66 TV participants were 71% and 60% male, respectively. The overall sample ranged in age from 20 to 71 with a mean of 30, averaged 3.4 years of education beyond high school, and had median annual income of $75,000 (all monetary values throughout are converted from Norwegian kroner to U.S. dollars at current exchange rates). Although the demographics of the sample are not representative of the Norwegian general population, the above average income and education levels are similar to "greener" segments in other studies (Grail Research 2009; Schwartz and Miller 1991) and hence can be considered a stronger test for the presence and size of the green value–action gap.

Conjoint analysis model

Full-profile conjoint analysis was used to determine attribute importance due to its ability to simulate decision making that involves attribute tradeoffs (Vriens 1994; Green, Krieger and Wind 2001). Published product reviews and interviews with industry experts were used to select the conjoint model attributes and levels for both product categories, with attention given to including "real world" negatively correlated attributes and levels that were important to consumers. This process resulted in a 4 attribute x 3 attribute-level model, with both products sharing three attributes: (1) technology type (hybrid, diesel, and gasoline powertrains for cars; LED, LCD, and plasma screens for TVs), (2) energy use (including the directly related CO_2 emissions for cars and yearly electricity bill for TVs), and (3) performance (0 to 100 kph acceleration for cars; screen resolution for TVs). Attribute 4 represented safety for cars (i.e., three-, four-, or five-star NCAP collision safety ratings) and screen size for TVs (i.e., 32, 37, and 42 inch). Pre-testing revealed that respondents were unlikely to have accurate knowledge regarding TV electricity consumption, which was resolved by translating energy use into yearly electricity bills on the TV conjoint cards. Similarly, some respondents were not highly familiar with strong and weak levels of car acceleration and TV screen resolution, so general descriptors were also added to the raw attribute level figures (see Appendix for questionnaire).

To keep the conjoint model simple while allowing consideration of other important non-included attributes, such as brand and product type, respondents were told to imagine they were shopping among alternatives of their favorite brands (i.e., Sony, Samsung) and product type (i.e., SUV, compact). A fractional factorial design generated nine product profiles (cards), and respondents were asked to evaluate each card on two dependent measures: (1) a 7-point purchase intention (PI) scale and (2) an open-ended "price they would expect to pay" (PE) for the described car or TV. The PE measure is similar to that employed in brand valuation research (i.e., Steenkamp, Van Heerde and Geyskens 2010), and pre-tests revealed that the answers given by respondents would reflect the total utility of the described bundle of attribute levels, which would allow a comparison with actual retail prices on a much wider basis than the alternative of using a price attribute with only three or four levels. After completing the conjoint card task, respondents answered questions covering demographics and green attitudes and behavior.

Real world choice sets

The conjoint results were then used to predict consumer choice among four sets of closely matched cars and TVs (see Tables 3 and 4). Each comparison set was chosen to minimize differences between alternatives not reflected by the conjoint model attributes. For example, to reduce alternative explanations for predicted outcomes, each comparison set contains similar models from the same brand (with one exception) to eliminate brand, quality, warranty, styling, and other non-technology related product variations (i.e., similar number of HDMI ports on TVs and similar engine size on cars). The Toyota Auris, Mercedes-Benz M-Class, and VW Toureg are the only car models currently offered with comparable full hybrid, diesel, and gasoline powertrains, thus the fourth comparison set uses diesel and gasoline versions of the VW Golf and the Toyota Prius hybrid, which are otherwise very similar in size, power, hatchback body style, price, and brand prestige. Similarly, the TV comparison sets reflect all three brands currently selling models using all three screen technologies, but lack of perfect correspondence on screen size between technology models from the same manufacturers means that two of the comparison sets involve plasma TVs with slightly larger screens than their LED and LCD counterparts.

Actual product performances/specifications on each attribute were collected from well-respected consumer testing media and/or manufacturer websites. Tax-free retail prices were used in all calculations to eliminate the varying levels of tax breaks and penalties that many governments give to green and brown alternatives respectively. To allow comparisons across choice sets of varying price levels, indexes were created where the least green technology (i.e., gasoline cars and plasma TVs) was used as the baseline (i.e., value of 100), with the greener alternative's differing performance, specification, and prices reflected by higher or lower relative index values. Thus for prediction purposes the relatively low price class Toyota Auris' 29% hybrid price premium versus its gasoline counterpart can be compared to the 36% hybrid price premium of the medium price class VW Toureg. Similarly, the PE conjoint results were standardized so that attribute level coefficients reflect a percentage of the conjoint model constant (i.e., base price) rather than a fixed monetary value to allow predictions across choice sets with varying price levels. Least squares linear regression was run on each respondent's conjoint coefficients within each of the performance, energy use, and screen size attributes to allow coefficient predictions for each car's/TV's attribute values (i.e., the conjoint coefficients were the predictors of the actual attribute level values). For example, the regression based trend line for the 0-100 kph time of the performance attribute, which covers levels of 8, 10, and 12 seconds, is used to predict each car respondent's conjoint coefficient for the 10.4 second performance of the Toyota Prius. This process allows the calculation of each alternative's total utility to accurately reflect possible attribute tradeoffs.

Attribute tradeoff confirmation

The tradeoffs among the car attributes are confirmed by regression results using the four comparison sets from Table 3. Variables comprised of powertrain type (i.e., Hybrid = yes = 1 or no = 0) and index values of price and acceleration (i.e., percent of gasoline version) are used as predictors of the indexed energy use dependent variable. Normally the car safety attribute is expected to be negatively correlated with environmental friendliness, due to heavier, less efficient cars being statistically the safest type of vehicle (IIHS 2009), but for purposes of this analysis the safety attribute was eliminated from calculations due to all database cars having the maximum five-star rating. The regression results indicate that hybrid and diesel powertrains reduce energy use by 19.5 and 16.4 percentage points respectively versus gasoline, while negative coefficients on technology-induced price and acceleration values indicate that a 10% lower price or 10% faster acceleration will result in 4.3% and 8.5% energy use increases respectively. Thus holding other factors constant, the 33% decrease in acceleration times since the 1970s noted earlier would result in a 28% increase in fuel consumption. These attribute relationships among the choice set cars confirm that shoppers wishing to make the greenest possible purchase should choose the slowest cars employing the highest priced hybrid technology.

Similarly, attribute tradeoffs are confirmed with regression results involving the four TV choice sets from Table 4. Predictors are comprised of dummy variables for screen technology (i.e. LED = yes =1 or no = 0) and resolution (i.e. highest resolution = yes = 1 or no = 0), and index values of screen size and price (i.e. percent of plasma version), while an index value of energy use is used as the dependent variable. The regression results indicate that LED and LCD technologies reduce energy consumption by 37.9 and 22.4 percentage points respectively versus plasma. A positive relationship between energy use and screen technology induced price differences is also reflected by regression results indicating a 10% increase in price will result in a 3.4% reduction in energy use. Positive coefficients on screen size and resolution indicate, however, that a 10% larger screen or a one-step increase in resolution will result in 38% and 24% increases in energy use respectively. Thus holding other factors constant, the 35% increase in average screen size during 2004–2007 would result in a 133% increase in electricity consumption. These attribute relationships among the choice set TVs indicate that the greenest possible choice has the smallest screen, lowest resolution, and employs the highest priced LED technology.

Results

The PI-based conjoint equation constants displayed in Tables 1 and 2 (i.e., 3.30 for cars and 3.08 for TVs) are added to single attribute level coefficients on each attribute to predict the purchase intention evaluation of the respondent on a 1 to 7 scale with higher values indicating increased purchase likelihood. Similarly, the PE-based conjoint equation constants of $44,974 and $1,162 for the cars and TV respectively indicate the ”base” price expectation from which the dollar value attribute level coefficients are added or subtracted to predict the expected price for each configuration. Larger relative differences between most and least preferred attribute levels indicate the increased importance of the attribute in explaining the variance of each respondent’s conjoint card evaluations. Conjoint results for both the product samples, and using both PI and

PE values as dependent variables, show Pearson's R at .97 and above (i.e., correlation between the conjoint model's predicted scores and the actual respondent scores on each of the conjoint cards), which indicates good attribute understanding and high consistency in respondent preferences for the differing attributes levels displayed on each card.

------ Tables 1 and 2 about here -------

The PI car results in Table 1 show that diesels are the most preferred powertrain with the highest average coefficient (.0784) and are the top choice of 48.5% of the sample, while 44.1% of the sample prefers hybrids (coefficient -.0123). Gasoline powertrains are the least preferred, with an average coefficient of -.0662 and the top choice of 36.8% (note the total is greater than 100% due to tie scores). Subjects also generally prefer faster acceleration, higher safety, and lower energy use (and emissions). PI attribute importance calculations show that technology type is the least important attribute, explaining 4% of the conjoint result variance, while energy use/emissions is most important at 35%.

The PE car results follow the same rank order of preference as PIs, but relative importance does shift as illustrated by comparing the greenest and least green car configurations. Using the overall car sample results from Table 1, the predicted PI score for the greenest car (i.e., hybrid with slowest acceleration and best fuel economy) would be: 3.30 + -.0123 + .4951 + -.6152 = 3.25. In comparison, the predicted PI score for the least green car (i.e., gasoline with fastest acceleration and worst fuel economy) is 3.05, or 6.3% less than the greenest car. The same calculations using the PE conjoint coefficients shows that the greenest car's expected price is $44,167, which is .1% less than the least green car's $44,548. This difference between PI and PE results provides moderate support for H1 ($p < .1$), as the PI based desire for green technology and better fuel economy is eliminated by the PE valuation for faster acceleration.

The PI TV results in Table 2 show that LED is the most preferred technology with the highest average coefficient (.0307) and is the top choice for 56.1% of the sample. Plasma screens are the least preferred, with a coefficient of -.508 and the top choice of 9.1%. Respondents also generally prefer higher screen resolution, larger screens, and lower energy use. PI attribute importance shows that screen technology is the least important attribute, explaining 22% of the conjoint result variance, while screen size is most important at 29%.

As with the cars, the PE TV results follow the same rank order of preference as PIs, but with differing green attribute and level relative importance. Thus for the overall TV sample, the predicted PI score for the greenest possible TV (i.e., 32-inch LED with lowest energy consumption, and highest screen resolution) is 3.88 (note the high resolution coefficient is used here because all LED TVs are high resolution). In comparison, the predicted PI score for the least green TV (i.e., 42-inch plasma with highest energy consumption and highest resolution) is 3.15, or 23% less than the greenest TV. Doing the same comparision with PE shows that the greenest TV is valued at $1,196, while the least green TV is valued at $1,390, or 14% higher than the greenest choice. Thus the difference between the PI and PE provides support for H1 ($p < .01$), as the strong preference for energy savings and the green LED technology when using PI is overwhelmed by the valuations given to the larger screen size in the PE results.

Conjoint analysis product preference prediction results

The conjoint results of each respondent are used here to predict the proportion that would choose the greenest technology alternative among the real world car and TV choice sets using their relative product specifications and prices as displayed in Tables 3 and 4.

------ Tables 3 and 4 about here -------

The PI-based values show that, across the four car choice sets, 43.4% of respondents would have hybrid cars as their top choice, while 47.8% would choose the diesel, and 9.9% would choose the gasoline version, indicating a strong preference for the greener technologies and most efficient/clean models. Moreover, the PE-based price index indicates that consumers are well aware that green technologies carry a price premium, as they expect to pay 13% more for a hybrid than a comparable gasoline car. The 13% hybrid PE premium is considerably lower than the actual retail price premium average of 25%, however, which translates into only 20.9% of respondents having a hybrid PE that exceeds the actual hybrid price premium (i.e., only 20.9% of respondents expect a hybrid to have a price premium of 25% or more). The opposite is true for diesels, where the 18% average PE premium is higher than the actual average retail price premium of 11% versus gasoline equivalents, meaning that over 60% have a diesel PE that exceeds the actual diesel price premium.

Behavioral choice is predicted by using PI and PE together, where the final choice is based on the alternative with highest PI ranking also offering a PE utility that exceeds the actual retail price premium versus the least green alternative. The combined measure results support H1's value–action gap prediction, as hybrid projected share drops significantly ($p < .01$) from a PI based 43.4% to a combined measure share prediction of 11.8% across the four choice sets. The highest individual hybrid prediction is 16.2% for the Prius and the lowest is 2.9% for the VW Toureg hybrid. Most of these would-be hybrid buyers are thus predicted to choose a 29% less efficient/clean gasoline equivalent instead (see Table 3 for energy use comparison), with the gasoline powertrain's predicted share significantly increasing to 35.7% across the four choice sets ($p <. 01$).

A similar pattern is shown for the TV predictions, as the PI-based values across the four TV choice sets show that 55.3% have the most energy efficient LED TVs as their top choice, while only 24.6% choose the least energy efficient plasma version, indicating a strong preference for the greenest technology. As with the cars, the respondents are also aware of the higher price that accompanies the greenest technologies, as the sample expects to pay 17% more for LED TVs versus plasma equivalents. A comparison between the actual retail price index and the PE-based index again reveals, however, that the expected 17% price premium is far less than the actual 42% retail price premium, which translates into only 25.8% of respondents having a LED PE exceeding the actual LED retail price premium (i.e., PE is greater than 42%). Thus using PI and PE together to predict TV choice also shows an H1 supporting value–action gap, as predicted LED share drops significantly ($p < .01$) to 25% across the four choice sets, with the highest individual LED prediction being 48.5% for the LG 42-inch and the lowest of 3.0% for the LG 47-inch. Most of these PI predicted LED buyers are thus expected to choose a 52% less efficient plasma equivalent instead (see Table 4 for energy use comparison), with the predicted plasma share increasing significantly to 59.1% across the four choice sets ($p < .01$).

H2 predicts that energy saving technologies that also provide advantages on other conventional attributes (as LED TVs do on picture quality) will be chosen more frequently than green technologies that provide few additional advantages (as with hybrid cars). The PI results support H2, as LED is preferred by more than two to one over second place plasma, while hybrids are actually less preferred than dirtier diesel cars. H2 is also supported when attribute tradeoffs are taken into account, as the LED TV's combined measure (i.e., PI and PE) share is over twice as high as the hybrid's predicted share (25% versus 11.8%, $p < .05$).

Characteristics of green buyers

Tables 5 and 6 display the environmental profiles of respondents who are predicted to choose the different technology offerings across the four choice sets. The hybrid buyer profile supports H3, as they are significantly greener than predicted buyers of both gasoline and diesel cars. Predicted hybrid buyers are 6% higher than average on light car usage (i.e., more frequent use of public transit or cycling for transportation needs), currently drive cars that get 3% better fuel economy, are 14.7% more likely to purchase the most efficient home appliances, and recycle 20.1% above the average (all significant at $p < .05$). On attitudinal measures, they are 10.1% above average in concern for the environment, 13% more concerned about energy savings, and 3.6% less concerned about finding the cheapest alternative ($p < .05$). This pattern is also significantly reflected in their conjoint results, as their PE for hybrid versus gasoline cars is 170.2% above average, while their PE for the most efficient/clean cars versus the least efficient/clean is 90.7% above average ($p < .01$).

------ Tables 5 and 6 about here -------

In contrast, gasoline and diesel purchasers seem to be driven by utilitarian needs rather than a desire to be green. Gasoline car buyers are generally not heavy car users, suggesting that their limited driving would make the potential fuel saving of diesels and hybrids less important to their choice. Although gasoline buyers are somewhat above average on some non–driving related green behaviors, they are also 12% more likely to look for the cheapest alternatives, such as their preferred gasoline cars, and only average on their attitudes toward the environment and energy savings. Conversely, predicted diesel buyers are heavy car users and currently drive thirsty cars, suggesting they would benefit greatly from a diesel's better fuel economy relative to gasoline equivalents. They also report below average green behaviors and little relative interest in environmental issues, thus there is no evidence to suggest that buyers of the "light green" diesel cars are greener than buyers of brown gasoline cars.

The TV results indicate that LED TV buyers do not generally have a greener profile than buyers of LCD and plasma TVs, and thus provide support for H4. LED buyers are 24.7% more likely to be heavy car users, 42% less likely to be light car users, 9.1% less likely to choose green appliances, and 3.5% less likely to recycle than the overall average ($p < .05$). Attitudinally, they are 6.9% and 6% below average respectively, in their environmental and energy saving concerns ($p < .01$). As would be expected, their conjoint PE valuations are 1,468.4% higher than average on LED technology versus plasma, but they also have 66.1% higher valuations on the best screen resolution, 8.3% higher valuations on the largest screen size, and almost no valuation for the lowest energy use ($p < .05$). These profile values strongly suggest that their LED choice has very little to do with the environment and more to do with having the best technology for enhanced viewing pleasure. Table 6 results also indicate no clear pattern of green behavior and attitudes among predicted buyers of less green LCD or plasma TVs. Thus the environmentally concerned segment that dominates predicted hybrid car buyers is not present in any concentrated form among the predicted buyers of any TV screen technology. Instead, those predicted to choose the most efficient LED TVs seem to base their choice on the higher quality viewing experience rather than green benefits or values.

Product specification rebound effects

The results reported at the bottom of Tables 5 and 6 support the product specification rebound effects predicted by H5, as green technology buyers in both product categories show a small but significantly ($p < .05$) stronger preference for higher energy consuming attribute levels.

Based on purchase intention results for the 0-100 kph acceleration attribute of the conjoint model (i.e., % of sample with highest preference for 8, 10, and 12 second acceleration times), the predicted hybrid and diesel buyers prefer a slightly faster car (8.8 seconds) versus buyers of thirstier gasoline cars (9.0). Using the regression results previously described in the Attribute Tradeoff Confirmation section, these faster acceleration preferences translate into a 1% higher fuel use for predicted hybrid and diesel buyers versus gasoline when holding all other factors constant. The same process reveals a rebound confirming preference among predicted LED TV buyers for a 40.8-inch screen versus 40.3 and 40.2 for LED and plasma buyers respectively, which results in a 2% higher energy use prediction for LED buyers due to the tradeoff between screen size and energy consumption. While these effects are small, it should be noted that the overwhelming desire among the entire sample for the fastest acceleration and biggest screens (see Tables 1 and 2) probably created a ceiling effect that prevented bigger product specification rebound effects from occuring.

Discussion and conclusion

This study demonstrates that value–action gaps are created by green attribute tradeoffs, which limit the market share and environmental impact of green products. While it is widely known that green products typically carry a higher price than do conventional alternatives, the results of the current study also show that other green tradeoffs, such as reduced size and performance, can also limit their appeal to consumers. For green product marketers, the good news is that most respondents appreciate and financially value green technologies and benefits, but closing the value–action gap will require a reduction in the current level of green tradeoffs with conventional attributes. This is shown by the almost 50% of car respondents expressing a preference for hybrid cars, although the current tradeoffs mean that less than 12% are predicted to buy one across the four comparison sets. Even this relatively low market share estimate is considerably higher than actual hybrid share, which currently accounts for less than 3% of new car sales in the United States and less than 1% in Europe (Olson 2012). On TVs, over half of the respondents prefer the energy efficient LED technology, but only 25% are predicted to choose it across the four comparison sets. In contrast to hybrid cars, however, this prediction is actually below the current 34% LED share of the large screen size market (NPD Weekly 2011).

One reason for these share inaccuracies is due to the choice sets used for predictions, which assume that the buyer considers only three equivalent products that vary mostly in their technology and technology dependent characteristics but not on other factors such as brand or features. This assumption gives an unrealistic advantage to hybrids, because gasoline and diesel alternatives are much more numerous in the real world. For example, a European buyer of the best-selling Toyota Prius hybrid can choose among three trim levels but has no options in terms of engine power or body style. In comparison, the VW Golf offers a choice of 12 diesel and gasoline engines, although no hybrid version, and over 50 trim and body style options with widely varying prices and capabilities. Thus a consumer comparing a Prius with a Golf would have much more opportunity to find a Golf with their most desired combination of performance, features, and price, which is a likely reason the Golf outsells the Prius by 10 to 1 in Europe.

For TVs, the opposite is true, as currently only Panasonic, Samsung, and LG offer plasma versions, while the more efficient LED and LCD TVs are offered not only by these three brands but also in hundreds of variations by many other brands such as Sony and Philips. Furthermore, even among most current plasma producers, there are a greater variety of offerings in the LCD and LED technologies, particularly related to screen size and features. Thus the comparison sets used in the current study give an advantage to plasma that is not matched in the real world, which deflates the share estimate for LED and LCD TVs.

Limitations and future research

Although cars and TVs represent two major sources of greenhouse gas emissions and natural resource use, future research might examine if attribute tradeoff type and severity are also key explanatory factors for the adoption success or failure of green alternatives in other product categories. For example, the attribute tradeoffs of relatively successful green products, such as hydroelectricity, video-conferencing, and e-books, might be compared with less successful green products, such as solar power, biofuels, and electric cars. Another limitation of the current study is its reliance on a Norwegian sample that is likely to be above the global average in environmental concerns, therefore a replication of the current study might examine the degree to which attribute tradeoffs effect green product adoption by demographic groups with lower interest and financial means to “go green”.

Future research might also further address the rebound effect implications of corporate and government success in promoting the widespread adoption of energy saving green products. While the current results show support for product specification based rebound effects, future investigations might determine their presence on other attributes that are negatively correlated with energy use/emissions such as product size (i.e. larger cars or refrigerators) or energy using features (i.e. self-cleaning ovens, 4 wheel drive). These together with the more traditional product use and product purchase rate rebound effects might be examined to determine the full extent of the energy and emission givebacks that are associated with the choice of energy efficient green products. Such investigations might also examine cognitive justifications for rebound effects through the use of a moral self-licensing framework, which predicts that the sacrifices entailed by choosing a green alternative might cognitively "justify" the non-green behaviors that lead to rebound effects (Davis 2008; Mazar and Zhong 2010). For example, moral self-licensing might be used to determine if guilty feelings caused by a preference for an energy-thirsty SUV are offset by paying extra for the hybrid version (or vice versa). Comparisons in relative rebound effects or use of moral self-licensing might also be made between dark green segments, who sacrifice to buy green products such as hybrid cars, and less green segments, who buy green products such as LED TVs for non-green reasons.

Managerial and public policy implications

The current results suggest that a large portion of consumers prefer green technologies and benefits and expect to pay a price premium for them, which indicates that the value–action gap is not due to a lack of green product awareness among consumers. The results also show that products such as hybrid cars, which offer few non-green advantages over browner alternatives, are likely to attract only the small dark green segment of consumers unless current attribute tradeoffs are substantially reduced. In contrast, the LED TV results show that the technology's picture quality advantages help to justify its higher price and make the product attractive to non-green customers. Thus a key managerial and public policy implication is that widespread green product adoption will likely require green tradeoff reductions and/or compensation for the tradeoffs by offering important advantages on non-green attributes versus brown alternatives.

Reducing prices directly or indirectly (i.e., via creative financing schemes) may be one method to overcome the tradeoffs that frequently accompany green product adoption, but only if such discounts are viable for their manufacturers and sellers. Thus another likely requirement for green product market share gains is manufacturer and retailer margins that are sufficient to profitably allow more competitive pricing. Profits are also a likely explanation for the demand dampening sparse assortment of hybrid cars and demand enhancing plentiful assortment of LED TVs. LED TVs are profitable to manufacturers and retailers, and prices have been dropping, making them even more popular with consumers. In comparison, hybrid cars generally provide lower profits than conventional alternatives, in large part due to the need for both gasoline and electric powertrains, but also because they have been less attractive to mass markets and hence have not provided manufacturers with cost reducing economies of scale (Olson 2012). Therefore, marketing strategies that attempt to position green products as exclusive and expensive status symbols are unlikely to be financially or environmentally successful when the low sales do not achieve substantial environmental benefits or overcome green product cost handicaps.

In the short term, government policies may play a key role in green product diffusion, as subsidies can provide compensation to consumers, manufacturers, and distributors for the unattractive green product tradeoffs. Government subsidies to the recently bankrupted solar panel producer Solyndra and the slow selling Chevrolet Volt plug-in hybrid suggest that government support may not be enough to overcome tradeoff-related weak market demand. Furthermore, government subsidies for green products are expensive, and current budgetary problems are forcing government cutbacks around the world. Thus to avoid subsidy costs, governments may consider legal mandates that force manufacturers to provide more efficient/cleaner products (i.e., water use standards for toilets, incandescent light bulb bans). Such mandates may increase the availability of green products but will not in themselves reduce the tradeoffs that currently make many green products unattractive to consumers as the opening quotes suggest. Therefore, the long-term closure of the value–action gap among consumers is likely to require scientists and designers to develop green products that eliminate the unattractive attribute tradeoffs that push most buyers toward browner compromise alternatives, while green product marketers will need to devise marketing mixes that convince sceptical consumers that its easy being green.

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Appendix
Questionnaire

Conjoint Card Example – 1 of 9 cards:

Characteristics of the car:

Engine Technology:	Gasoline
CO_2 Emissions:	100g CO_2 per kilometer (Low Emissions)
0-100kph Acceleration:	10 seconds (Moderate Performance)
NCAP Safety Rating:	3 stars (Adequate Safety)

Would Definitely Not Buy ← 1 – 2 – 3 – 4 – 5 – 6 – 7 → Would Definitely Buy

If you were to buy a car with these characteristics, how much would you expect to pay: _______

Attitudinal, Behavioral and Demographic Questions:

1. What is the fuel economy of the car you drive most often: ________ liters per 10 kilometers.
2. When traveling to school or work during a typical week, what portion of your travel used the following: ____% walking or biking, ____% public transit, _____% personal car (1)
3. When purchasing household appliances, I always buy the most energy efficient model. (2)
4. I always use a recycling center or in some way recycle my household trash. (2)
5. I always purchase the lowest price product, regardless of its impact on the environment. (2)
6. I am very concerned about the environment. (2)
7. I feel an obligation to save energy whenever possible. (2)
8. Gender: _____ Male, _____ Female
9. Age: _____ years
10. Annual Income: _______ kroner
11. Education Beyond High School: ______ years.

Notes: (1) = heavy car user does majority of travel with car. Light car user does minority with car. (2) = questioned were answered with a 1 to 7 strongly disagree ←→ strongly agree scale.

Table 1

Car Conjoint Model

Conjoint Model Car Attributes and Leve	Purchase Intention Coefficient	Price Expectation Coefficient	Price Expectation Std. Coef. (1)	Purchase Intention Top Choice %	Highest Expected Price %	PI Attribute Importance	PE Attribute Importance
Powertrain Technology						4.05%	13.83%
Hybrid	-0.0123	-$176.20	-2.44%	44.10%	27.90%		
Diesel	0.0784	$2,090.35	7.26%	48.50%	52.90%		
Gas	-0.0662	-$1,914.15	-4.82%	36.80%	19.10%		
Economy & Emissions (2)						34.78%	29.91%
.87 lp10k & 200g CO2	-0.7451	-$4,079.37	-10.84%	5.90%	1.50%		
.65 lp10k & 150g CO2	0.25	-$499.34	1.55%	44.10%	33.90%		
.49 lp10k & 100g CO2	0.4951	$4,578.71	9.29%	69.10%	64.70%		
0-100kph Acceleration (3)						30.31%	19.04%
12 seconds	-0.6152	-$2,933.75	-8.52%	13.20%	13.20%		
10 seconds	0.1495	$355.05	-0.83%	35.30%	30.90%		
8 seconds	0.4657	$2,578.70	9.36%	72.10%	55.90%		
Collision Safety Rating						30.86%	37.22%
3 Star	-0.5343	-$5,209.30	-13.65%	11.80%	5.90%		
4 Star	-0.0319	-$357.35	1.40%	27.90%	17.60%		
5 Star	0.5662	$5,566.66	12.25%	77.90%	76.50%		
Constant	3.2966	$44,974	100%				
Pearson's R	0.97	0.992					

(1): standardized as % of constant, (2) 1 liter per 10K = 23.5 MPG, (3) 0-100 KPH = 0-62 MPH.

Table 2

TV Conjoint Model

Conjoint Model TV Attributes & Levels	Purchase Intention Coefficient	Price Expectation Coefficient	Price Expectation Std. Coef. (1)	Purchase Intention Top Choice %	Highest Expected Price %	PI Attribute Importance	PE Attribute Importance
Screen Technology						0.22	0.28
LED	0.307	$166	12.33%	56.10%	53.70%		
LCD	0.202	-$53	-3.58%	34.80%	26.90%		
Plasma	-0.508	-$114	-8.75%	9.10%	17.90%		
Annual Energy Cost						0.26	0.06
$50	0.502	$21	2.51%	75.80%	27.30%		
$100	-0.024	-$39	-3.59%	19.70%	19.70%		
$150	-0.478	$18	1.08%	4.50%	53.00%		
Screen Resolution						0.23	0.17
720-50	-0.339	-$82	-6.96%	7.60%	9.10%		
1080-50	-0.178	-$9	-1.11%	18.20%	34.80%		
1080-100	0.517	$91	8.07%	74.20%	56.10%		
Screen Size						0.29	0.48
32 inch	-0.526	-$244	-20.49%	6.10%	0.00%		
37 inch	-0.008	$11	1.07%	10.60%	11.90%		
42 inch	0.535	$233	19.41%	83.30%	87.90%		
Constant	3.08	$1,162	100%				
Peasons R	0.987	0.992					

(1): standardized as % of constant.

Table 3

Car Comparison Set Results

Brand, Model, & Powertrain Technology	Energy Use & Emission Index Liters/100k	Performance Index Acceleration 0-100kph	Tax-Free Retail Price Index	Price Expectation Index	Customer Purchase Intention Top Choice	% Willing to pay Premium	Customer Value Top Choice
VW Toureg Hybrid SUV	82	83	136	117	72.1%	8.8%	2.9%
VW Toureg Diesel SUV	78	109	108	119	27.9%	69.1%	67.6%
VW Toureg Gas SUV	100	100	100	100	4.4%		29.4%
Mercedes ML450 Hybrid SUV	79	99	118	109	55.9%	13.2%	7.4%
Mercedes ML350 Diesel SUV	82	92	107	110	20.6%	55.9%	51.5%
Mercedes ML350 Gas SUV	100	100	100	100	23.5%		41.2%
Toyota Auris Hybrid compact	60	114	129	109	35.3%	27.9%	20.6%
Toyota Auris Diesel compact	76	119	107	118	55.9%	36.8%	26.5%
Toyotal Auris Gas compact	100	100	100	100	8.8%		52.9%
Toyota Prius Hybrid compact	65	109	116	117	10.3%	33.8%	16.2%
VW Golf Diesel compact	74	98	121	125	86.8%	79.4%	64.7%
VW Golf Gas compact	100	100	100	100	2.9%		19.1%
Hybrid Average	71	101	125	113	43.4%	20.9%	11.8%
Diesel Average	77	104	111	118	47.8%	60.3%	52.6%
Gas Average	100	100	100	100	9.9%		35.7%

Table 4

TV Comparison Set Results

Brand, Screen Size, & Screen Technology	Energy Cost Attribute Index	Screen Resolution Attribute Dummy	Screen Size Attribute Index	Retail Price Attribute Index	Price Expectation Index	Customer Purchase Intention Top Choice	% Willingness to Pay Premium	Customer Value Top Choice
LG 47 LED	39	1	94	131	103	47.0%	3.0%	3.0%
LG 47 LCD	58	1	94	105	89	15.2%	25.8%	24.2%
LG 50 Plasma	100	1	100	100	100	37.9%		72.7%
LG 42 LED	51	1	100	150	136	68.2%	48.5%	48.5%
LG 42 LCD	56	0	100	109	111	19.7%	59.1%	19.7%
LG 42 Plasma	100	0	100	100	100	12.1%		31.8%
Samsung 40 LED	36	1	93	147	124	71.2%	28.8%	28.8%
Samsung 40 LCD	53	0	93	138	99	18.2%	7.6%	1.5%
Samsung 43 Plasma	100	0	100	100	100	10.6%		69.7%
Panasonic 42 LED	66	1	100	139	104	34.8%	22.7%	19.7%
Panasonic 42 LCD	92	1	100	108	96	27.3%	31.8%	18.2%
Panasonic 42 Plasma	100	1	100	100	100	37.9%		62.1%
average LED	48	1.0	97	142	117	55.3%	25.8%	25.0%
average LCD	65	0.5	97	115	99	20.1%	31.1%	15.9%
average Plasma	100	0.5	100	100	100	24.6%		59.1%

Table 5

Car Buyer Demographics, Green Attitudes, Behaviors, and Rebound

	Hybrid	Diesel	Gas	Overall (13)	Scheffe G vs. H vs. D p < .05 (14)
n % predicted to choose (1)	12.20%	33.50%	54.40%		
Male %	118.7	99.1	100.6	70.60%	GH, HD
Age	94.4	100.9	101.5	29.4	GH, HD
Income (2)	89.2	97.6	101.7	$79,150	GH, GD, HD
Education (3)	80.4	97.6	107.5	3.41	GH, GD, HD
Environment Concern	110.1	99.7	99.7	5.59	GH, HD
Energy Saving Concern	113.0	100.2	99.7	5.44	GH, HD
Heavy Car User (4)	105.1	112.9	77.9	32.40%	GH, GD, HD
Light Car User (5)	106.0	88.1	119.1	39.70%	GH, GD, HD
Current Car Economy (6)	103.0	94.3	106.8	0.71	GH, GD, HD
Always Buy Green Appliances	114.7	99.1	101.0	4.47	GH, HD
Always Recycle	120.1	93.6	105.5	5.16	GH, GD, HD
Always Buy Cheapest Option	96.4	108.7	88.0	4.07	GH, GD, HD
PE Hybrid vs. PE Gas (7)	270.2	105.7	40.6	0.10	GH, GD, HD
PE 8 sec vs. PE 12 sec (8)	110.6	101.2	87.6	0.18	GH, GD, HD
PE 5 star vs. PE 3 star (9)	137.9	96.1	91.3	0.26	GH, HD
PE 100g vs. PE 200g (10)	190.7	87.4	84.6	0.20	GH, HD
Preferred 0-100 acceleration (11)	8.8	8.8	9.0	8.90	GH,GD
Predicted Energy Use Index (12)	101.0	101.0	100.0	100.50	GH,GD

(1): % is weighted portion choosing each powertrain across the 4 choice sets, (2): annual household income, (3) years education beyond high school, (4) heavy car use = use car for most transport needs, (5) light car use = use public transit, biking etc. more than car, (6) current car economy in liters per 10K, (7) expected price difference between hybrid and gas, (8) expected price difference between fast and slow car, (9) expected price difference between 5 star and 3 star crash rating, (10) expected difference between cleanest and dirtiest car, (11) based on purchase intention preference on acceleration attribute conjoint results, (12) based on predicted acceleration effect on energy consumption, (13) column is non-indexed mean value for sample, (14) GH=gas buyer significantly different than hybrid, GD=gas significantly different that diesel, HD=hybrid buyer significantly different than diesel.

Table 6

TV Buyer Demographics, Green Attitudes and Behaviors and Rebound

	LED	LCD	Plasma	Overall (13)	Scheffe P vs. E, C p < .05 (14)
n % (1)	25.00%	15.90%	59.10%		
Male %	113.3	90.0	98.2	58.20%	PE, PC, EC
Age	95.1	118.9	95.3	30.4	PC, EC
Income (2)	98.4	115.9	94.2	$69,833	PE, PC, EC
Education (3)	76.5	109.0	111.0	2.00	PE, EC
Environment Concern	93.1	100.4	102.1	5.78	PE, PC, EC
Energy Saving Concern	94.0	104.3	100.8	5.60	PE, PC, EC
Heavy Car User (4)	124.7	130.7	84.1	32.80%	PE, PC
Light Car User (5)	58.0	113.9	125.5	41.80%	PE, PC, EC
Current Car Economy (6)	132.3	82.4	87.3	0.58	PE, EC
Always Buy Green Appliances	90.9	111.5	98.9	4.12	PE, PC, EC
Always Recycle	96.5	92.6	102.8	5.37	PE, PC, EC
Always Buy Cheapest Option	102.6	84.6	104.4	4.33	PE, PC, EC
PE LED vs. PE Plasma (7)	2468.4	64.5	47.8	0.21	PE, PC, EC
PE 42 inch vs. PE 32 inch (8)	108.3	110.3	93.7	0.40	PE, PC
PE 1080 vs. PE 720 (9)	166.1	84.4	76.2	0.15	PE, EC
PE 500 vs. PE 1500 (10)	0.5	184.8	119.4	0.01	PE, PC, EC
Preferred Screen Size (11)	40.8	40.3	40.2	40.40	PE, EC
Predicted Energy Use Index (12)	102.2	100.2	100.0	100.60	PE, EC

(1): % is weighted portion choosing each technology across the 4 choice sets, (2-6): see table 5 explanations, (7) expect price difference between LED and plasma, (8) expected price difference between big and small screen, (9) expected price difference between highest and lowest resolution, (10) expected difference between lowest energy bill and highest, (11) based on purchase intention preference on screen size attribute conjoint results, (12) based on predicted screen size effect on energy consumption, (13)column is non-indexed mean value for sample (14) PE = plasma buyer significantly different than LED, PC = plasma significantly different than LCD, EC = LED buyer significantly different than LCD.