NBER WORKING PAPER SERIES

ADVERTISING AS INSURANCE OR COMMITMENT? EVIDENCE FROM THE BP OIL SPILL

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Working Paper 19838
http://www.nber.org/papers/w19838

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
January 2014

Previous versions of this working paper were circulated with the title: “Advertising, Reputation, and Environmental Stewardship: Evidence from the BP Oil Spill.” We thank Ryan Kellogg, Matthew Kahn, Richard Schmalensee, and Jesse Shapiro for helpful comments. Phillip Ross provided outstanding research assistance. Hastings gratefully acknowledges funding through Brown University, Department of Economics and Population Studies and Training Center. Chyn gratefully acknowledges support in part from an NICHD training grant to the Population Studies Center at the University of Michigan (T32 HD007339). The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 19838
January 2014, Revised July 2016
JEL No. H0,H23,L0,M3,M38,Q5

ABSTRACT

This paper explores how advertising impacts the consumer response to news about unobserved product quality. Specifically, we estimate how British Petroleum's (BP) 2000-2008 "Beyond Petroleum" advertising campaign affected the impact of the 2010 BP oil spill. We find that BP station margins declined by 4.2 cents per gallon, and volumes declined by 3.6 percent after the spill. However, pre-spill advertising significantly dampened the price response in the short-run, and reduced the fraction of BP stations switching brand affiliation in the long-run. Our results suggest that advertising provides insurance against adverse events. We discuss implications for private provision of environmental stewardship.

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A data appendix is available at http://www.nber.org/data-appendix/w19838

1 Introduction

How does advertising shape consumer behavior and firm incentives to undertake costly, hidden investments in product quality? Theoretical models generate ambiguous predictions as to whether advertising serves as an informative commitment to provide product quality (Shapiro, 1983; Cabral, 2005), or plays a persuasive role that protects firms even in the event of negative product news (Minor and Morgan, 2011). Hence, the relationship between advertising and product quality is an open empirical question.

This paper provides novel evidence on this question by studying the impact of advertising on consumers' response to news about product quality. Specifically, we study the consumer response to the British Petroleum (BP) Deepwater Horizon Oil Spill in 2010, one of the largest oil-related environmental disasters to date.[1] Prior to the spill, BP undertook one of the largest and most successful corporate advertising campaigns entitled "Beyond Petroleum." Between 2000 and 2008, BP rebranded its gasoline stations with a new logo – a Helios (sun) symbol – and a new name behind the BP acronym (Beyond Petroleum replaced British Petroleum). Both moves were designed to reflect the company's newly stated dedication to environmental stewardship – a commitment to take more expensive production decisions to mitigate environmental degradation. The campaign launched with a $200 million budget and won a prestigious advertising award from the American Marketing Association in 2007. Anecdotally, these marketing efforts appeared to have an effect as U.S. consumer surveys and press reviews consistently rated BP as

[1] In April 2010, an oil well blowout caused multiple explosions and led to the eventual sinking of the Deepwater Horizon oil drilling rig. An estimated 205.8 million gallons of oil flowed from the well in the ensuing weeks (National Commission, 2011). Despite containment efforts, the spill led to the world's largest accidental release of oil into marine waters. On November 5, 2012, BP formally pled guilty to charges of *environmental crimes*, and agreed to pay $4 billion to settle its criminal case with the United States government (United States of America v. BP Exploration & Production, Inc. CDN: 2:12-cr-00292-SSV-DEK).

the most environmentally friendly oil company during the mid-2000s (Landor Associates, Cohn & Wolfe, and Penn, Schoen, & Berland Associates 2007, 2008).

The Beyond Petroleum campaign and subsequent oil spill are a natural setting for measuring the impact of news about unobserved quality on consumer demand, and testing whether pre-period advertising investments dampened or amplified the demand response. We combine detailed data on gasoline station prices and sales from January 2009 to March 2011 with supplemental data on both metropolitan-level BP advertising data during the 2000s and measures of local area environmental preferences. This allows us to estimate the impact of the spill on retail demand for BP gasoline and examine how effects varied over time and across areas with different levels of pre-spill advertising exposure and green preferences.

We find the following. First, there was a significant consumer response to the BP oil spill. BP retail prices declined 4.2 cents per gallon relative to non-BP stations in neighboring markets. This represents a 25 percent decrease in margins relative to industry standards. In addition, BP volumes declined by 3.6 percent among our sample of station customers (fleet card holders). Further, over the course of the spill, BP prices and volumes fell with increasing intensity: the negative impact of the spill peaked at a 6.1 cents per gallon price decrease and a 6.7 percent volume loss in August 2010.

Second, the estimated impact is significantly stronger in areas where consumers exhibit greener preferences. Following List and Sturm (2006), Kahn (2007), and Kahn and Vaughn (2009), we create a Green Index based on local demand for green products, as well as memberships in and contributions to environmental organizations. We find the impact was more intense in areas with stronger green preferences and less intense in higher-income areas, all else equal. The positive correlation between green preferences and income mitigated the impact on BP retail performance in "green" markets.

Third, we find that the consumer response to the spill was significantly reduced by pre-spill exposure to BP advertising. We measure advertising using data from Kantar Media (formerly known as CMR, TNS Media Intelligence, and KMR Group).[2] The data include BP's monthly advertising units and expenditures across newspaper, billboard, radio, television, and internet by metropolitan area. Our core ad spending measure focuses on corporate advertisements (i.e., ads related to the BP Corporation, BP fuels, and environmental issues) during the Beyond Petroleum campaign (2000-2008). To address the potential endogeneity of advertising expenditures, we use market-level TV spot prices as an instrument for variation in BP advertising across cities. We find that the impact of the oil spill on BP prices was significantly less severe in areas with more BP pre-spill advertising. These results are robust to a variety of specification checks such as controlling for BP's corporate advertising during the spill and for other types of advertising that may have affected demand for BP-branded retail gasoline stations.

Finally, we also find long-term effects of the oil spill. The impact on BP prices and quantities changed sharply after the leak was sealed in September 2010. BP prices increased to slightly higher than pre-spill averages relative to stations in comparison markets; however, fleet card volume sales remained significantly lower.[3] In addition, we find that markets with low pre-spill advertising suffered greater losses in BP retail outlet share. We find significant losses in BP's share of stations beginning around the time of the largest price impacts. The losses amount to a 5 percent decline relative to the mean and occur only in areas with low pre-spill advertising, suggesting that in these areas, during-spill profit losses may have been large enough to cause station owners to switch to alternative brands.

[2] TNS Media Intelligence acquired Competitive Media Research (CMR) in 2003. Kantar acquired both TNS and KMR group in 2008 (Chou et al. 2008, Clark et al. 2009).
[3] We provide a discussion of the interpretation of price versus quantity effects in Section 4.

Overall, our results suggest that BP's investment in the Beyond Petroleum advertising campaign cushioned the impact of the spill on demand. There are several possible explanations for this result. Minor and Morgan (2011) argue that expenditures on corporate social responsibility can provide insurance against reputational costs after product recalls by shifting beliefs about whether the event was due to negligence or bad luck. In this sense, advertising plays more of a persuasive role (Dixit and Norman, 1978; Schmalensee, 1976; Becker and Murphy, 1993; Bertrand et al., 2010[4]) than an informative role (Butters, 1977; Grossman and Shapiro, 1984), shifting valuations for a good rather than providing information and commitment to quality. Alternatively, this effect could also be generated by positive brand recognition or non-environmental brand value (such as habit formation) that buoyed demand despite revelations of lower-than-advertised environmental quality (Clark et al., 2009). While we only observe one history of BP advertising, we provide suggestive evidence on the protective effect of reputation-building through the environmentally-themed Beyond Petroleum campaign versus local and ancillary product ads that are more likely to affect demand through the latter channel. While both seem to have a positive effect, our results are consistent with a larger protective effect of environmentally-themed corporate advertisements in greener areas.

Our short- and long-run findings have potential implications for public policy. Specifically, governments (or other organizations) may be able to enhance

[4] Bertrand et al. (2010) find that non-informative advertising (e.g., a woman's photo) can affect demand significantly. In their setting, consumers had previously purchased the advertised product, thus effectively ruling out an informative channel. In our setting, consumers do not know the advertised product attribute at the time of purchase. By examining the effect of advertising on the consumer response to product quality news, we test whether advertising operated through persuasive or informative channels, and explore implications for product quality provision.

market efficiency by monitoring environmental stewardship claims. Such efforts may provide additional incentives for firms to internalize externalities.

2 Background

In July 2000, BP launched a $200 million public relations campaign focused on aligning the BP brand with environmental issues (PR Watch, 2010). The company introduced a new slogan, "Beyond Petroleum," and redesigned its logo to a green and yellow Helios sun. New advertising focused on environmental stewardship[5] and emphasized that BP was making its operations more efficient and working to reduce environmental impacts (Cherry and Sneirson, 2011). The campaign won two PR Week "Campaign of the Year" awards and received the prestigious Gold Effie Award from the American Marketing Association in 2007 (Solman, 2008).[6]

Anecdotally, consumers appeared to retain this environmental messaging. In 2008, the marketing firm Landor Associates surveyed consumers, asking "How green do you consider [BP] to be?" Survey results showed 33 percent believed BP was a "green" brand, and respondents ranked BP as the greenest of the major petroleum companies (Landor Associates, Cohn & Wolfe, and Penn, Schoen, & Berland Associates, 2007, 2008). A 2008 poll of 1,000 U.K. marketers ranked BP as third when asked which company made the greatest commitment to environmental issues (Marketing Week, 2008).[7]

Why did BP undertake this costly investment in environmental branding? Broadly speaking, empirical work has found that advertising generally increases

[5] For example, one TV ad featured a narrator asking "Is it possible to drive a car and still have a clean environment?" and "Can business go further and be a force for good?" Speaking on the behalf of BP, the narrator affirms: "We think so" (BBC News, 2000).

[6] PR Week, Brand Development Campaign of the Year (winner), International Campaign of the Year (honorable mention), Internal Communications Campaign of the Year (winner) for "Taking BP Beyond" (PR Week, 2010)

[7] At the same time, several environmental and advocacy groups, such as Greenpeace and Corpwatch, criticized BP's re-branding as "greenwashing" (Corpwatch, 2000).

demand for advertised products (e.g., Ackerberg, 2001; Bagwell, 2007; Dube and Manchanda, 2005; Bertrand et al., 2010; Clark et al., 2009; Simester et al., 2009; Lewis and Reiley, 2008; Hastings et al., 2013; Gurun et al. 2013). Previous research has also shown that consumers are willing to pay for environmental stewardship as a product attribute (e.g., Kiesel and Villas-Boas, 2013; Kahn and Vaughn, 2009; Kahn, 2007; Teisl et al., 2002; Roe et al., 2001; Nimon and Beghin, 1999; Goett et al., 2000; Forsyth et al., 1999; De Pelsmacker et al., 2006; Loureiro et al., 2001). Yet, while there may be demand for environmental quality, consumers do not know whether a product has this attribute in the absence of third party certification.

Since environmental quality is unobserved at the time of purchase, this suggests that there are at least two different motivations for firms to invest in advertising. On the one hand, some theoretical models have shown that firms investing in hard-to-observe product attributes (such as environmental stewardship) can use advertising as a sunk cost to credibly signal their investment in product quality (Shapiro, 1983; Milgrom and Roberts, 1983; Cabral, 2005). Alternatively, advertising could play a persuasive role that convinces consumers that negative events are accidental and occur due to "bad luck." This model was proposed by Morgan and Minor (2011) in the context of corporate social responsibility claims, and shares a persuasive flavor with Dixit and Norman (1978), Schmalensee (1976) and Becker and Murphy (1993). In this context, advertising can change customers' beliefs about underlying firm actions and acts as insurance to reduce the chance that customers interpret bad outcomes as due to shirking. This mitigates consumer punishment, decreasing firm incentives to follow through with product quality

promises.[8,9] In this sense advertising is a substitute for - instead of complement to - investments in unobserved product quality.

With this in mind, the BP Deepwater Horizon oil spill provides a unique setting to test whether advertising plays more of an informative or persuasive role. Shortly after the conclusion of the Beyond Petroleum advertising campaign, an oil well blowout caused multiple explosions and the eventual sinking of the Deepwater Horizon rig in April 2010. Afterward, robotic monitoring devices discovered that oil was leaking from the damaged well. Over the next few months BP engineers sought to contain the oil leak, but were unsuccessful until a "containment dome" was placed over the leaking well in July 2010. [10] With the capping of the well, government-appointed scientists estimated that nearly 205.8 million gallons of oil had leaked from the well (Department of Interior, 2010). On September 19, 2010, BP completed the relief well, and officials declared that the damaged well was "effectively dead." Subsequent investigations confirmed that the cause of the spill was attributable to active management decisions on behalf of BP.[11]

[8] More broadly, models of ex-ante unobservable product quality provision have found that firms must face financial sanctions for false product quality claims (such as advertising) as incentives for equilibrium quality provision (see Cabral (2005) for a survey of this literature). Models of private provision of public goods have similarly formalized this point (Besley and Gathak, 2007). In addition, punishment may be more difficult if deviation is hard to detect. In our setting, negative news about environmental stewardship may only occur probabilistically. Consumers must infer events are the result of shirking on quality promises, and decrease demand accordingly.

[9] Several studies have analyzed the impacts of negative product news on demand, such as recalls of consumer products (e.g., Crafton et al., 1981; Reilly and Hoffer, 1983; Minor and Morgan, 2011; Freedman et al., 2012), airplane crashes (e.g., Borenstein and Zimmerman, 1988) and lawsuits involving medical services (Dranove et al., 2012). They do not examine advertising and baseline claims of product quality.

[10] Aigner et al. (2010).

[11] A non-partisan commission found that "the immediate cause of the blowout could be traced to a series of identifiable mistakes made by BP" and its contractors, further concluding that "(w)hether purposeful or not, many of the decisions that BP, Halliburton and Transocean made that increased the risk of the Macondo blowout clearly saved those companies significant time (and money)" (National Commission, 2011). The Department of Justice concluded that "the explosion of the rig was a disaster that resulted from BP's culture of privileging profit over prudence" (DOJ, 2011).

Our analysis begins by estimating the impact of the BP oil spill on station-level retail gasoline prices and volumes (as measured in our customer sample of fleet card holders). We then examine how the consumer response varied across markets that varied in two key dimensions: their willingness to pay for environmental products (measured using a variety of proxies) and their exposure to BP's corporate advertising preceding the spill. The latter constitutes our test for whether advertising had a persuasive effect. Specifically, we examine whether BP stations suffered greater losses in markets which received high levels of pre-spill advertising. In addition, we explore whether advertising had an impact in the long-by examining changes in the share of stations affiliated with the BP brand.

3 Data

3.1 Gasoline data

We use data on retail gasoline prices, sales to fleet-card customers, and station brand affiliations to estimate the impact of the BP oil spill on gasoline prices, sales, and long-run branding decisions. The data come from the Oil Price Information Service (OPIS), which collects information on gasoline station prices and sales from two sources. First, OPIS records information on prices and volumes from Wright Express fleet fuel card "swipes". Wright Express reports the last transaction of the day at each station to OPIS and calculates a price based on that transaction's total sales amount and gallons sold.[12] This information is available only for stations that accept this fleet card and available only on days when fleet card transactions

[12] As with all scanner data, this can result in errors in prices. Because only the last purchase of the day is reported, it is more difficult to clean out errors than in scanner data for which many purchases are recorded for the same product each day. Prices are more accurate in recent years as more purchases are recorded for more stations each week and the data become easier for Wright Express and OPIS to clean. We drop only one percent of price observations based on large one-day changes in prices indicative of an error in data. Note that for gasoline stations that offer personalized discounts (e.g. grocery store chains), variation in OPIS retail prices may reflect both changes in street price as well as differences in per-gallon discounts available to the customer who post the last purchase of the day.

happen (i.e., an individual must use their fleet card for a price to be recorded for a particular station on a particular day).[13] The fleet card is widely accepted across the U.S. Second, since 2009, OPIS has expanded its data collection to include reporting agreements with several gasoline refiner-marketers that provide retail prices for some stations that do not accept the fleet card.[14]

Between these two sources, the OPIS data have a price observation for over 100,000 stations in the United States. However, most stations are available only for a portion of the years 2009-2011 or have sporadically reported prices. Given our interest in station-level variation in prices and sales over time, we focus on zip codes in which OPIS reporting meets minimum density criteria.[15] Each zip must have at least five stations with at least three price observations per week for our entire sample period. We keep data for all stations located in this list of zip codes.

In our empirical results, we compare prices at BP stations to a control group of stores in zip codes without any BP stations present. To be clear, this control group excludes non-BP stations in close proximity to BP stores as their prices were likely impacted by the spill as well. This leaves us with a sample of 7,503 stations. As a robustness check, we reproduce our main analysis using all of the OPIS data, regardless of whether stations are missing large portions of data or whether most competitors in the station's area are not in the OPIS data. The results for this unfiltered sample are very similar and can be found in Online Appendix Section II.

For stations in our sample that accept fleet cards (as opposed to stations whose parent companies only report prices to OPIS), we observe weekly total gasoline sold through fleet cards. Although fleet card customer preferences may be different than the population average, these data provide a glimpse into the consumer response to the events of interest. While limited, these data represent, to

[13] See also Busse et al. (2013) for another description of these data.
[14] For a list of stations that accept the fleet card see www.wrightexpress.com.
[15] Further details on how we clean the data and define our sample are in the Online Appendix.

our knowledge, the only station-level volume data currently available.[16] We follow an analogous procedure to select zip codes with sufficient fleet sales coverage (see Online Appendix). For the volumes data, we are left with 6,735 stations of which 6,709 are also in our price sample. Again robustness checks using the entire sample of treatment and control stations produce very similar results and are reported in the Online Appendix.

In addition to prices and fleet sales, each observation includes a station's location, brand of gasoline, and brand of convenience store in each week. Our main analysis uses each station's initial brand in our sample (from January 2009) to categorize it as a BP or non-BP station in order to avoid potential brand endogeneity due to stations switching away from the BP brand after the spill. We analyze such switching behavior in a separate analysis in Section 4.3.

Finally, we use weekly gasoline spot prices from the Energy Information Administration (EIA) to compute a measure of retail margins (EIA, 2011). Specifically, we define a weekly station-level net price as the average price for station i in week t less the average New York spot price in week t:[17]

$$netprice_{it} = AveRetailPrice_{it} - EIANewYorkSpot_{t} \quad (1)$$

We focus on weekly net prices to abstract from daily variation and because most stations do not post prices for every day during a week (data are typically available up to six days per week). In our regression specifications, we weight weekly price and quantity observations by the underlying number of daily observations within the week.

[16] The alternative panel data on gasoline sales volumes of which we are aware are state-aggregated (over all brands and suppliers) sales volumes reported to the Energy Information Administration (EIA) by oil companies through survey responses (Hastings and Shapiro, 2013).

[17] We use the NY spot price instead of the Gulf spot price because several hurricanes hit this area during our sample period, causing a few instances of spot price spikes that were not reflected in our NY spot or retail price series.

3.2 Advertising data

We measure advertising using Kantar Media Ad$pender data which report expenditures by date and marketplace for more than three million brands across 18 media formats.[18] Kantar uses tracking technologies and services to monitor television advertising on both cable and network stations, print media expenditures from over a thousand business-to-business and consumer magazine and news publications, and internet sites. They collect outdoor and local radio advertising information from other marketing subscription services and directly from media providers (e.g., radio stations or billboard plant operators).[19] Given a fixed combination of time period, market, and media type, advertising expenditure data are hierarchically categorized through product levels that identify the parent company (e.g., BP vs. Shell), distinguish between brands (e.g., BP service station vs. Amoco service station) and differentiate between products to which a brand is attached (e.g., BP energy utilities vs. BP gasoline).

Our data set tracks BP advertising from 2000 through 2011 and all other advertising from 2007 through the 2011.[20] In our main specification we use advertisements during the years of the Beyond Petroleum campaign (2000-2008) that focused on the BP Corporation, BP fuel products, and environmental issues. Our main analysis aggregates all advertising expenditures across all media as our measure of advertising exposure. This specification assumes there are stock effects of advertising on demand (Dube and Manchanda, 2005).

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[18] The 18 media types provided by Kantar Media include network television, spot television, cable television, Spanish language network television, syndication, magazines, business-to-business magazines, Sunday magazines, Hispanic magazines, local magazines, national newspapers, local newspapers, Hispanic newspapers, network radio, national spot radio, local radio, U.S. Internet and outdoor activities.

[19] For more details, see Ad$pender manual (Kantar Media, 2011). See also other papers that have used these data, including Saffer and Dave (2006), Reuter and Zitzewitz, (2006), Chou et al., (2008), Clark et al. (2009) and Gurun et al. (2013).

[20] Ad$pender data licenses cover a rolling five year period; historic data must be purchased separately and at a significant premium.

Since BP advertising may be endogenous to each area's unobserved preference for the BP brand, we instrument for BP's advertising using television advertising spot prices across all industries and product categories. We focus specifically on the quantity-weighted average spot television advertising price from 2007-2008. This price provides a measure of advertising cost differences across metropolitan areas.[21] Our identifying assumption is that cross-sectional differences in demand and supply for general spot television advertising do not lead to differences in the consumer response to the BP oil spill other than through their impact on BP advertising levels. Note that previous studies in advertising use this type of instrument (Dube and Manchanda 2005; Izuka and Jin 2005; Choi, Shin-Yi, and Grossman, 2008; Liu and Gupta 2011; Dinner, Van Heerde, and Neslin 2014). We discuss the plausibility of the identifying assumption in section 4.2.1.

3.3 Measures of Green Preferences

The literature characterizes green preferences in a variety of ways. For example, List and Sturm (2006) use per capita membership in environmental organizations at the state level. Kahn (2007) uses California Green Party registrations and shows that they are a significant predictor of demand for green products, such as hybrid vehicle registrations. Kahn and Vaughn (2009) create a green index based on California referendum voting outcomes and Green Party registrations; they document that hybrid vehicles and LEED-certified ("green") buildings cluster in politically green communities. Building on this literature, we compile and combine the following measures to create a green index:[22]

[21] We match the Kantar data, which are at the Designated Market Area (DMA) level, to zip codes using the county-DMA correspondence provided by Gentzkow and Shapiro (2008), in conjunction with a county-zip correspondence from the U.S. Department of Housing and Urban Development.

[22] We also experimented with including measures of Democratic Party committee contributions and Barack Obama's vote share from the 2008 presidential election. However, these measures appeared to decrease the explanatory power of the green index.

1) Hybrids: Share of hybrid-electric vehicle registrations in 2007 in each zip code obtained from R.L. Polk automotive data. We chose the year 2007 to exclude hybrid car purchases caused by the 2008 spike in gasoline prices.
2) Sierra: Per capita Sierra Club membership in 2010 at the state level created using data from the Sierra Club and the U.S. Census Bureau.
3) LEED: The number of LEED-registered buildings per capita in each zip, obtained from the U.S. Green Building Council (accessed in June 2011).
4) Green Party Contributions: Average per-capita contributions to Green Party committees in 2003-2004 and 2007-2008 at the zip code level, computed using individual level data from the Federal Election Commission.[23,24]

We aggregate these variables into a single "Green Index" by computing Z-scores for each of the measures and summing them. We also consider each zip code's hybrid vehicle share as an alternative measure of green preferences.

4 Empirical Analysis

4.1 Pooled results

We begin by examining the impact of the BP oil spill on station prices and fleet card sales. We regress station net price or fleet sales on station fixed effects, indictors for during- and post- spill periods, and interactions of those time period dummies with an indicator of whether a station sells BP-branded gasoline:

$$y_{it} = \alpha_i + \beta^1 during_t + \beta^2 post_t + \theta^1 during_t * BP_i + \theta^2 post_t BP_i + \varepsilon_{it} \qquad (2)$$

Here, y_{it} is either average net price or the log average fleet sales for station i in period t, α_i is a station-level fixed effect, $during_t$ is an indicator if period t is during

[23] The Federal Election Commission data cover all individual contributions over $200.
[24] To maintain comparability with income data, contributions are converted to 1999 dollars using the Bureau of Labor Statistics' CPI inflation calculator.

the oil spill, $post_t$ is an indicator if period t is after the spill, and BP_i is an indicator of whether station i sells BP-branded gasoline.

We aggregate daily prices and quantities at two levels. First, a concern is that autocorrelation in net prices or fleet sales data might bias the standard errors (Bertrand et al., 2004). To address this, we collapse all weekly net price and fleet sales data into averages within three time periods: a *pre-spill* period (January 01, 2009 through April 16, 2010), a *during-spill* period (April 23, 2010 through September 17, 2010), and a *post-spill* period (through March 2011). Results from this aggregation are presented in Table 1, columns 1 and 2. Second, we use weekly net price and fleet sales data for comparison in Table 1, columns 3 and 4.[25]

Across specifications we find that there is a negative, economically and statistically significant effect of the oil spill on both prices and sales at BP stations relative to the control group. BP stations experienced a relative price decrease of 4.2 cents per gallon and a 3.6 percent drop in sales from fleet customers.[26] This decrease in net price is substantial, given that the National Association of Convenience Stores estimates that the average retail mark-up was 16.3 cents per gallon in 2010 (NACS, 2011). Using this statistic, the point estimate represents a 26 percent decline in retail margins. These effects are, however, temporary: in the post-spill period, retail station prices at BP stations rebound although quantities remain depressed.

Figure 1 displays the mean weekly price (level) for the BP and control stations in our sample. The vertical lines denote the beginning and sealing of the oil spill, respectively. For much of the period prior to the spill, our sample of BP

[25] In both specifications, the aggregate observations for each station in each time period are weighted by the number of underlying observations from the disaggregated (daily) data.

[26] Because our measure of volume comes from fleet sales, we prefer reduced-form regressions for price and quantity. Using our data to estimate structural parameters of the change in preferences resulting from the spill would require an assumption that fleet sale demand is the same as non-fleet sale demand (which we do not observe). In addition, as prices and sales are not available at all stations, estimating a demand system based on a random utility model is problematic.

stations has higher prices, on average, compared to the control group. Almost immediately following the oil spill, the mean price for BP falls below the control price until the spill is capped. Several months following the spill, BP's prices rise above control station prices. This pattern is consistent with the following interpretation: advertising increased demand from marginal consumers pre-spill, those consumers decreased demand during and after the spill. BP re-optimized post-spill to their new demand curve to sell to the most loyal, but smaller subset of consumers. If these consumers were less price elastic, BP's new equilibrium price should increase and quantity sold should fall.

Table 2 estimates the month-by-month change in BP prices and fleet sales relative to control stations. After the spill, BP stations experienced a small, immediate drop in net price (1 cent per gallon) with no discernible impact on fleet sales. Net prices continued to fall, bottoming out in August at -6.1 cents per gallon. During the same month, BP stations experienced a 6.7 percent reduction in fleet sales compared to control stations. At this point, nearly 205.8 million gallons of oil had spilled into the Gulf and only 17 percent had been captured by BP's containment efforts (New York Times, 2010).[27] By October, the price impact had declined to 0.5 cents per gallon, with quantities remaining lowered by 2.4 percent.

Figure 2 plots the point estimates from Table 2 against Google search intensity relative to January 2004 for the phrase "oil spill." For a given month, the Google search intensity is measured as the ratio of searches in that month to searches during a baseline month. Here, the baseline month is January 2004, so a value of 50 indicates that searches in a baseline month were 50 times greater than they were in January 2004. The number of searches for the term "oil spill" intensified dramatically in early May 2010 and peaked on June 4th, one day after a BP apology campaign began airing. The results suggest that public interest in the

[27] Among the rest, eight percent had been burned or skimmed, 25 percent evaporated or dissolved, 24 percent dispersed either naturally or chemically and 26 percent still at sea or on shore.

spill was significant and that the relative magnitude of the price response appears to lag the spike in online searches.

Our identifying assumption is that, aside from the oil spill, there was no shock to gasoline prices (and quantity sold to fleet vehicles) that affected BP and competitor stations differentially from non-BP/non-BP competitor stations in the aftermath of the oil spill. Although plausible, this assumption could be violated if, for example, BP stations are more likely to be in zip codes that are less (more) likely to be subject to summertime gasoline Reid Vapor Pressure (RVP) standard regulations than zip codes in which our control group stations lie.[28] This could disproportionately drive down (up) the relative price of gasoline in markets with BP stations in the summer, as content regulations can cause local seasonal increases in gasoline prices through increased production costs. Because the BP spill occurred during the spring and summer of 2010, differential regulations could be a confounding factor.

Table 3 restricts the sample to zip codes with no seasonal gasoline content regulation (uniform RVP of 9.0). The results show a *stronger* overall BP price decrease of 7.5 cents per gallon. Fleet sales impacts cease to be significant, although the point estimate remains negative. It should be noted that the Table 3 specification reduces our sample size by over 70 percent. Indeed, when considering a larger sample of standard RVP zip codes from the unfiltered OPIS data (i.e., not restricted to our list of "good" sample zip codes), the quantity impacts are stronger and remain highly significant in this specification as well (see Online Appendix Section II). Overall, seasonal changes in RVP gasoline content requirements do not appear to be driving our results.

These findings suggest that, on average, BP stations suffered losses to revenues as a result of the BP oil spill. Our results are consistent with both short-

[28] See Brown et al. (2008) and Auffhammer and Kellogg (2011) for detailed descriptions of gasoline content regulations.

run punishment and a more permanent loss of some customers post-spill. They are consistent with models of trust, where a consumer expects a firm to behave a certain way and punishes it for deviating from that behavior for a period of time, and with reputation models, where consumers expect firms to be a particular type (e.g., high quality) and update their beliefs permanently in response to an experience sufficiently different from their expectation. Trust models primarily address moral hazard (e.g., shirking on promised quality effort), whereas reputation models primarily deal with adverse selection (e.g., low quality types pretending to be high quality types). Both may have happened for different consumers, generating the observed changes in prices and sales during and after the spill.

Note that trust models that involve many consumers suffer from a similar problem to voting; punishment is not individually rational as each individual consumer's demand is not sufficiently large enough to affect aggregate outcomes or incentives.[29] This may explain why consumers organize boycotts as coordinated responses to firm behavior, as many did during the BP spill.[30,31] Alternatively, Fehr and Gaechter (2000) find in laboratory experiments that subjects are willing to expend resources to punish deviating players even in a single-shot trust game, where such punishment cannot incentivize better future behavior, suggesting that punishment of bad behavior may have intrinsic value.

[29] See the literature on the paradox of not voting (e.g., Downs, 1957; Olson, 1965; Palfrey and Rosenthal, 1985; Feddersen, 2004).

[30] Calls for boycotting BP stations were issued by voices including Public Citizen, Jesse Jackson, and the Backstreet Boys, who reportedly completed their 2010 tour without stopping at BP stations to refuel their tour bus (Backstreet Boys, 2010).

[31] Models of civic duty, peer pressure and group voting have been put forward as social mechanisms to overcome the paradox of not voting. See for example Gerber and Green (2000), Green and Gerber (2004) and Coate and Conlin (2004).

4.2 Interaction and advertising effects

Table 4 examines how the price and sales impacts vary with measures of local green preferences and income. We merge onto our base data zip code level income data from the 2000 U.S. Census, the share of all registered cars in a zip code that are hybrid vehicles, and our Green Index as described in Section 3. We focus on the pre-spill versus during-spill periods to facilitate interpretation of interaction terms. Our regression reduces to a pure difference-in-difference estimation, with the difference in net price or total sales during the spill versus the pre-spill period at each station *i* as the dependent variable. We demean each of our interaction variables (income in 2000 U.S. thousands of dollars, hybrid share of registered vehicles) and interact them with an indicator for BP brand affiliation.

The first two columns repeat the results in Table 1 on the subsample of stations for which the Green Index, hybrid car shares, and income data are all available. The results are essentially unchanged. Columns 3 and 4 add controls and interactions for income and hybrid shares. Income has a positive and significant association with the price changes at BP stations, indicating that the negative impact of the spill was abated in high-income areas. A one standard deviation increase in income (of $15,563) implies a 1.55 cents per gallon (0.001*$15.563) smaller price decrease than the average. This difference represents an approximately 39 percent reduction in the price decrease relative to the overall impact of -4 cents per gallon. The smaller price effects seen in high income areas may be driven by gasoline station selection and by higher valuation of convenience. We find a negative and significant association between income and quantity sold through fleet cards. A one standard deviation increase in income at the zip code level reduces BP volumes during the spill period by an additional 3 percentage points (-0.002*$15.563) relative to our sample mean of -3.6 percent. Thus, while BP prices drop less in high-

income areas, BP fleet card customer sales drop more, though we note that fleet card sales may not be reflective of overall demand relevant for price setting.

Price effects were larger in areas with larger shares of hybrid vehicles. The results imply that a one-standard deviation increase in hybrid vehicle share is associated with an additional 0.6 cent per gallon (-0.012*0.5%) drop in BP retail gasoline prices in the aftermath of the spill. However, the hybrid vehicle share interaction term is not a significant predictor of changes in BP sales after the spill. Columns 5 and 6 of Table 4 substitute our Green Index for percentage of hybrid vehicles, as described in Section 3, compiling measures of green preferences used by List and Sturm (2000), Kahn (2007) and Kahn and Vaughn (2009). Using this measure, we again find that greener areas responded more strongly to the BP oil spill. The coefficient on Green Index implies that a one standard deviation increase in the Index intensifies price decreases by 0.94 cents per gallon (-0.006*1.56), or a 23.4 percent further decrease relative to a mean decrease of 4 cents per gallon. We do not find a significant interaction effect between the Green Index and changes in fleet-card volume sold at BP stations, however fleet card sales may not be reflective of overall demand relevant for price setting.

Finally, Table 5 adds interactions with demeaned BP advertising expenditures to test if advertising during the Beyond Petroleum campaign is associated with higher or lower price and sales impacts. Our main specification measures advertising as total expenditures aggregated over all forms of advertising in our Kantar data, which includes television, newspapers, magazines, radio, billboards and Internet spending (Clark et al., 2009) for ads that focused on the BP Corporation, BP fuel products, and environmental issues during the Beyond Petroleum campaign years (2000-2008). If this advertising convinced consumers of BP's commitment to the environment through investments in production processes that provide an environmental public good (or reduce negative externalities), one might expect to see steeper losses at BP stations in areas with

heavier Beyond Petroleum advertising. On the other hand, in the early days of the spill, such advertised claims could have swayed consumers' beliefs about whether the disaster was due to bad luck or bad management, leading to softer price and sales impacts (Minor and Morgan, 2011).

The first two columns of Table 5 replicate the benchmark results from Table 1 for the sample of stations that have income, green preference, and advertising data available. The average impact of the spill is slightly smaller in this sample, but remains economically and statistically significant. Columns 3 and 4 add demeaned advertising and its interactions with an indicator if the station was a BP station and an indicator for the post-spill period. The results suggest that pre-spill exposure to BP advertising significantly dampened the impact of the oil spill. The point estimate on the interaction term *BP*Advertising* suggests that a one standard deviation increase in advertising expenditure softened the price impact of the spill by about 1 cent per gallon (0.003*3.4), resulting in a 24 percent decline in the price impact of the spill. The effects of the spill on BP station prices in high income and high Green Index areas remain unchanged; the coefficients on these interaction terms are similar to those in Table 4. We find no significantly different effect of the spill on quantities sold in areas exposed to more versus less advertising. On the one hand, a negative demand shock accompanied by an outward supply shift (i.e., BP lowering prices sufficiently) may result in an equilibrium with lower prices but unchanged quantities. On the other hand, sales to fleet card customers may not be representative of the population segment relevant for station price-setting, as discussed previously.

4.2.1 Instrumental Variables and Identification of Advertising Effects

Advertising may be endogenous to other factors that are correlated with local demand response to the BP spill. For example, advertising may be correlated with BP station market share. Market share may also be correlated with customer perceptions of BP brand quality or with the set of alternative non-BP brand stations

they could substitute towards. Suppose that advertising prices were correlated with BP's share of gasoline stations in a metropolitan area or with the number of gasoline station options. In this case, advertising would be correlated with consumer response to the oil spill as BP customers would have fewer non-BP gasoline options nearby, and would therefore be less responsive to the spill in their choice of station.

To address this endogeneity concern, we instrument for advertising expenditures using spot television advertising prices. Several papers in the literature develop similar instruments for advertising (Dube and Manchanda 2005; Izuka and Jin 2005; Choi, Shin-Yi, and Grossman, 2008; Liu and Gupta 2011; Dinner, Van Heerde, and Neslin 2014).[32] We use the quantity-weighted average spot price in the late Beyond Petroleum campaign years (2007-2008), when we have advertising data for all brands and all products in all product categories and industries (e.g., automobiles, clothing, etc.). First stage results are reported in full in the Online Appendix Table A0. To summarize, spot TV advertising prices are a highly significant predictor of advertising expenditures. The Shea's partial R-squared value is 0.69 in the first stage. Formal tests of instrument relevance strongly reject the null that the first stage coefficients on the excluded instruments are equal to zero (e.g., the Angrist-Pischke F-statistic leads to a rejection of the null with a p-value<0.0000).

The instrumental variables results in columns 5 and 6 of Table 5 are very similar in magnitude to the OLS results in columns 3 and 4. That is, our IV results confirm that the price effects of the spill were softer in areas where BP advertised

[32] Most similarly, Dube and Manchanda (2005) use the list price of gross rating points (an advertising measure), Choi, Shin-Yi, and Grossman (2008) use the price of advertising computed as dollars per seconds of messages aired (as well as the number of households in a DMA with a television set), and Izuka and Jin (2005) compute average wages in advertising-related occupations to capture advertising costs. Also relying on broad advertising market measures are Liu and Gupta (2011), who instrument for statin drug advertising with average advertising expenditures across all pharmaceutical firms and other drugs, and Dinner, Van Heerde, and Neslin (2014), who use non-direct competitor firm's advertising expenditures as instrument for firm's advertising expenditures.

more heavily during the Beyond Petroleum Campaign years. Indeed, the coefficient on price is stronger in the IV specification (0.4 cents per gallon spill impact protection per $1 million additional advertising expenditure), suggesting, if anything, that BP advertising was potentially higher in areas where it would have been punished more.

The instrument is valid under the assumption that spot prices are determined by the broad advertising market. This assumption would be violated if spot prices were instead determined by factors endogenous to the demand elasticity at BP gasoline stations *per se*; these factors would dampen the demand response to the oil spill in the absence of increased advertising. In the Online Appendix we investigate correlations between our instrument and other local area characteristics that could affect the demand response to the spill. Table A5 shows that spot TV prices vary positively and significantly with population density, but there is no detectable relationship with retail gasoline market concentration (HHI), BP station share, or gasoline station density. This suggests that spot advertising prices are orthogonal to key factors that might impact demand response at BP stations to the BP spill, such as BP market share and retail gasoline brand market concentration.

We also conduct several specification checks which directly control for the characteristics of local markets and which could affect the demand elasticity of BP gasoline stations. Columns 3 and 6 in Table A6 report results from specifications which add our measure of BP's market share in the metropolitan area to our main advertising IV specification. The results further confirm that BP station share is uncorrelated with our instrument since the point estimates on advertising's interaction with BP are very similar to our results in columns 5 and 6 of Table 5. Similarly, Table A7 also tests the robustness of our IV results by adding interactions with measures of the number of gas stations per square mile at the zip code level to our IV specifications. Adding these measures to our IV estimation has no impact on our advertising results, further confirming that our IV findings are not driven by

station density or concentration through more or fewer stations to substitute towards in response to the spill.

Since our instrument is specific to TV expenditures, we conduct another robustness check for our analysis by focusing on BP's spot TV advertising only (the excluded media are billboards, newspaper, radio and online spending). Online Appendix Tables A8-A9 show that focusing only on BP's spot TV advertising yields very similar results to our main analysis based on all media expenditures: a one standard deviation increase in BP's spot TV expenditures (+$2.2 mil) reduces the oil spill's impact on BP prices by 0.9 (OLS) and 1.3 (IV) cents per gallon. The instrument yields slightly higher Shea's partial R-squared values in the first stage regression as spot TV market prices are stronger determinants of spot TV advertising for BP than they are for all-media advertising. As before, we find no statistically significant advertising effect on quantities. Lastly, when we measure TV advertising in units of advertising we get similar results to using expenditures, namely that a one standard deviation increase in units of spot TV advertising (+1,080 ads) is predicted to mitigate the price effect of the BP oil spill by 1.1 (OLS) and 3.2 (IV) cents per gallon. Note that this measure counts all spot TV advertising units as equal whereas the expenditure measure counts advertising dollars as equal.

4.2.2 Interpretation

In summary, the positive and significant impact of advertising suggests that, rather than responding more strongly to the spill, consumers in high-advertising metropolitan areas were less likely to shift away from BP, lowering the impact of the spill on BP station prices. This result suggests that firms that provide low environmental quality in production may benefit from environmentally themed corporate advertising. Our results provide empirical support for the notion that investments in corporate branding may provide reputational insurance in case of adverse events, as suggested by Minor and Morgan (2011) for firm branding through investments in corporate social responsibility

Two main issues arise in interpreting these results. First, it may be the case that during-spill advertising is correlated with pre-spill advertising. Our data show an increase in BP advertising during the spill. These marketing efforts included informational advertising about relief and mitigation efforts (Tracy, 2010), which could have stemmed the impact of the spill on demand. We thus control for BP advertising *during* the oil spill in an augmented version of the main specification in Table 5. Table A10 shows that our estimates are robust to including during-spill advertising. Interestingly, column 2 shows that the price impact of during-spill advertising is also precisely estimated and has a slightly larger positive effect (per dollar of advertising) on reducing the consumer response to the oil spill.

A second issue for our interpretation is controlling for other forms of advertising that may have affected demand at BP stations and been positively correlated with Beyond Petroleum advertising (e.g., local ads by individual service stations and convenience stores). To address this concern, we exploit the fact that the Kantar data contain information on the corporate entity of the advertiser and the product advertised. Our main advertising measure focuses on corporate branding ads for the BP Corporation, BP fuels, and environmental issues, which were also likely to have contained Beyond Petroleum messaging. For our supplementary analysis, we create a second measure of advertising specific to local BP service stations, BP convenience stores, and ancillary products. (See the Online Appendix for further details.)

Using these data, we compare the effect of both categories of advertising. One caveat for this analysis is that both types of advertising may be endogenous, but we have only one instrument. Given this limitation, we report OLS results only. One reassurance for these results is that the similarity between the OLS and IV estimates in our main specification suggests that the endogeneity bias in these advertising estimates is minimal.

Table A11 shows that the estimated effect of our core corporate advertising measure from the Beyond Petroleum campaign is robust to controlling for other types of advertising that may have affected demand for BP retail gasoline stations. Column 2 shows that the point estimate for the impact of our core advertising measure is only slightly smaller than our main specification estimate re-produced in Column 1. Specifically, the point estimate shrinks from 0.3 to 0.2 cents per gallon per $1 million of corporate advertising during the campaign. Although imprecise, the point estimate for local and ancillary products advertising is positive, which suggests that these ads also cushioned the consumer response to the oil spill at BP stations. This may have occurred through channels such as habit formation or consumer loyalty (e.g.,to a local station owners).[33]

4.2.3 Long-run impact on station brand affiliation

Depending on the severity of the impact on station owners' profits, we might expect to see a long-run impact on BP through loss of station share as retailers switch affiliations to other brands. Most gasoline stations are owned or leased by independent dealers who sign long-term contracts with upstream refiners to sell and market a particular brand of gasoline.[34] If expected returns to the BP brand fall low enough, station owners may switch brand affiliations. This is a second, longer-term measure of the spill's impact on demand and long-run supply. We measure changes in BP's *share of stations* across zip codes before and after the oil spill, as well as how these patterns differ with BP advertising.

Specifically, we estimate the following specification:

[33] Prior literature suggests that advertising may operate through these additional channels. For example, Clark et al. (2009) also use Kantar advertising data linked to survey data on quality and brand awareness for firms across many sectors. They find that advertising has a larger impact on brand awareness than on quality perception (they do not, however, distinguish between advertising campaigns targeted at communicating quality versus brand awareness).

[34] Although many stations are not convenience stores, the National Association of Convenience Stores describes contracting and pricing generally among its members (NACS, 2012)

$$MarketShare_{z,t} = \mu_z + \sum_{-15}^{-1} \gamma_m \, 1(m = t) + \sum_{1}^{15} \tau_m \, 1(m = t) + \epsilon_{z,t} \quad (3)$$

where the dependent variable is BP's station share in zip code z in month t, γ_m are coefficients on dummy variables for each of the pre-spill months (before April 2010), τ_m are coefficients on dummies for each month after the spill (that is, after April 2010) and μ_z are zip code fixed effects. The omitted month is thus April 2010. The regression coefficients measure the change in station share relative to April 2010 controlling for zip code fixed effects. We estimate (3) separately for zip codes in metropolitan areas with above or below median BP ad spending during the Beyond Petroleum campaign years of 2000-2008. Figures 3A and 3B display the resulting coefficient estimates on the monthly time dummies with 95 percent confidence intervals for zip codes in above and below median advertising areas. Table A1 in the Online Appendix provides the corresponding regression tables.

The figures show no significant decline in station share in zip codes in high-Beyond Petroleum advertising areas, but a significant loss in below-median areas. The losses appear about six months after the oil spill, coinciding with the largest monthly drop in prices and sales volumes according to Figure 2. The loss in station share is sizeable, representing a five percent decline (-0.5% relative to a sample mean station share of 9.67%). The comparison of outlet share changes between areas with high and low pre-spill advertising suggests that advertising dampened longer term losses to BP in addition to softening the short-run negative impact of the spill on prices and sales.

4.3 Implications for Corporate Social Responsibility

An emerging applied theory literature has set out to explain the economic forces behind the private provision of public goods, motivated in part by the increasing popularity of corporate social responsibility (CSR) and environmental

branding (the Beyond Petroleum campaign being one example).[35] One strand in this research examines how strategic market interactions between firms and activists – "private politics" – can result in CSR provision (e.g., Baron, 2003; Baron and Diermeier, 2007). Another set of papers analyze markets for "impure public goods" which bundle private products with public good creation or the abatement of public "bads" (Besley and Ghatak, 2001, 2007; Kotchen, 2006).[36] In these models, private provision of public goods requires (i) consumers to value environmental stewardship, and (ii) consumers to punish firms for deviating from promised (advertised) product attributes.[37]

While we find that consumers value environmental stewardship, we also find that pre-spill corporate advertising during the Beyond Petroleum campaign *softened* the negative demand shift away from BP-branded gasoline. This finding is consistent with the idea that advertising provided reputational insurance, thus playing a persuasive role rather than serving as a commitment for BP to invest in environmental quality.

Ideally, we would differentiate the effects of advertised environmental stewardship from the effects of generic corporate branding that may also cushion against a negative demand shock. This would be done by observing the impacts of two separate advertising campaigns pre-spill, one with green messaging and one

[35] The majority of Americans now expect companies to engage in socially responsible practices such as environmental stewardship in production (Fleishman-Hillard and National Consumers League, 2007). Companies appear to be responding: A 2011 KPMG study found that 95 percent of Global Fortune 250 companies publicly report their social and environmental efforts (KPMG, 2011). In 2008, more than 3,000 companies provided reports dedicated solely to highlighting corporate social and environmental activities (Lydenberg and Wood, 2010).

[36] Kitzmueller and Shimsack (2012) discuss these papers in a review on the CSR literature.

[37] Other empirical evidence linking CSR investments and social bads include Kotchen and Moon (2011), who provide backward-looking evidence that firms with past "social irresponsibility" subsequently invest in CSR. They regress combinations of companies' current Kinder, Lydenberg, Domini Research & Analytics social responsibility indices on lagged values to test if past poor ratings (as measures of corporate social "irresponsibility") predict future good ratings (as measures of corporate social "responsibility"). Relatedly, Eichholtz et al. (2009) find that firms in certain 'dirty' industries, such as oil and mining, are more likely to lease green office space.

without. We can provide suggestive evidence by comparing the effects of our core corporate advertising measure with the effects of local and ancillary product ads. To do this we augment our advertising specification by adding interactions between the indicator for BP stations, each measure of advertising, and an indicator for whether a station is located in a zip code that has an above median green index score. While the estimates for these additional interaction terms are noisy, the results in Column 4 in Table A11 suggest that in high-green-preference markets, the Beyond Petroleum advertising had a larger dampening impact on demand response to the spill. In low-green-preference markets, however, the local station advertising had the larger dampening impact on demand response. This suggests that green advertising had larger protective effects where customers value the green-ness of their gasoline, while in markets where gas station loyalty is more likely driven by ancillary product services, advertising those products may have been more effective at preserving demand (perhaps habit formation is a potential mechanism here). This suggests that firm have incentives to build an advertising cushion on the dimension that local customers value most.

Overall, our results are consistent with the notion that consumers value environmental stewardship, but that their response to green advertising may give firms an incentive to "greenwash".[38] Though suggestive, this interpretation implies that the market's ability to effectively reward corporate social responsibility and provide public goods may be limited if CSR is communicated through advertising. These findings support the need for public or private environmental certification to monitor green product claims and suggest that regulation may be necessary to provide the incentives for firms to internalize the environmental repercussions of their production decisions.

[38] Greenwashing describes when firms mislead consumers about the environmental benefits and qualities associated with its products.

5 Conclusion

This paper studies how advertising affects the consumer response to new information about product quality. We explore this topic in the context of BP's 2000-2008 Beyond Petroleum advertising campaign and the subsequent BP Deepwater Horizon oil spill. Specifically, we estimate the effect of the oil spill on BP gasoline prices and sales, and examine how the spill's impact varied over time and across areas with different levels of green preferences, demographics, and exposure to BP corporate advertising. We find a statistically and economically significant (relative) decline in BP stations' prices and gasoline fleet card customer sales. This is consistent with a demand shift away from BP-branded gasoline in response to the spill. We also find that station margins suffered significantly larger losses in areas that exhibit green preferences as measured by proxies such as hybrid vehicle ownership or Green Party donations. This finding relates to a literature linking political green preferences with consumers' retail purchasing behavior (e.g., Kahn, 2007; Kahn and Vaughn, 2009) and provides evidence that consumers may be voting with their wallets to incentivize environmental protection.

Our analysis also shows that pre-spill exposure to BP advertising significantly dampened the spill's impacts on BP stations' prices. During the decade preceding the oil spill, BP embarked on a large and celebrated marketing campaign to brand itself as an environmentally friendly company. In the absence of formal certification schemes, advertising is a way for firms to signal and commit to product quality, including for environmental stewardship. However, our results suggest that corporate advertising may have led consumers to attribute the oil spill to bad luck rather than to negligent practices, potentially playing a persuasive rather than an informative role about environmental practices. This is consistent with the notion that expenditures on CSR may function more as insurance (Minor and Morgan, 2011). Finally, we also find that advertising cushioned BP from long-run,

negative impacts on sales as it decreased the fraction of gasoline stations who re-branded to other brands in the aftermath of the spill.

We conclude that our results suggest that advertising may fail to provide incentives for firms to undertake investments in hidden product quality attributes such as environmental stewardship in production. With regards to green advertising in particular, one implication of this finding is that there may be a need for public or private environmental certification to monitor green product claims, and that regulation may be necessary to provide the incentives for firms to internalize the environmental repercussions of their production decisions.

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TABLE 1: OIL SPILL IMPACT: BASIC DIFFERENCE ESTIMATES

	(1)	(2)	(3)	(4)
VARIABLES	Average Net Price	Ln (Ave. Fleet Sales)	Weekly Net Price	Ln(Weekly Fleet Sales)
During-spill	0.072**	0.019**	0.071**	0.032**
	(0.001)	(0.004)	(0.001)	(0.003)
Post-spill	-0.062**	-0.025**	-0.062**	-0.021**
	(0.001)	(0.005)	(0.001)	(0.004)
BP*During-spill	-0.042**	-0.036**	-0.042**	-0.040**
	(0.002)	(0.009)	(0.002)	(0.008)
BP*Post-spill	0.025**	-0.027*	0.025**	-0.027**
	(0.002)	(0.011)	(0.001)	(0.009)
Observations	21,421	19,430	763,985	695,166
Adjusted R-squared	0.933	0.965	0.741	0.852
S.E.cluster	station	Station	station	station
Weight	price observation	quantity observation	price observation	quantity observation
# stations	7,503	6,735	7,503	6,735

Notes: Source: OPIS. The price and quantity data cover the period from January 2009 to March 2011. Columns (1) and (2) report estimates where the dependent variable is the station's average net price and average log-quantity computed over the entire "pre-," "during-" and "post-" spill periods. Columns (3) and (4) report estimates when the dependent variable is the station's weekly net price and log-quantity. Each specification regresses the dependent variable on dummies for the during-spill period, a dummy for the post-spill period, and their interactions with a dummy for BP gas station. All models control for station fixed effects. Standard errors are clustered by station. Significance at 1%**, 5%*.

TABLE 2: OIL SPILL IMPACT BY MONTH

VARIABLE	Weekly Net Price (1)	Ln(Weekly Fleet Sales) (2)
BP*late_Apr'10	-0.011**	0.003
	(0.002)	(0.010)
BP*May'10	-0.041**	-0.030**
	(0.002)	(0.009)
BP*Jun'10	-0.049**	-0.063**
	(0.002)	(0.010)
BP*Jul'10	-0.044**	-0.049**
	(0.002)	(0.009)
BP*Aug'10	-0.061**	-0.067**
	(0.002)	(0.010)
BP*Sep'10	-0.029**	-0.010
	(0.002)	(0.010)
BP*Oct'10	-0.005**	-0.024*
	(0.002)	(0.010)
BP*Nov'10	0.021**	-0.040**
	(0.002)	(0.010)
BP*Dec'10	0.052**	-0.044**
	(0.002)	(0.011)
BP*Jan'11	0.049**	-0.031**
	(0.002)	(0.011)
BP*Feb'11	0.022**	0.012
	(0.002)	(0.011)
BP*Mar'11	0.028**	-0.033**
	(0.002)	(0.011)
Observations	763,985	695,166
Adjusted R-squared	0.839	0.860
Fixed Effects	station	Station
S.E.cluster	station	Station
Weight	price observation	quantity observation
# stations	7,503	6,735

Notes: Source: OPIS. The price and quantity data cover the period from January 2009 to March 2011. The dependent variables in Columns (1) and (2) are weekly net price and log-quantity, respectively. Each of these dependent variables is regressed on post-spill month dummies and their interactions with a dummy for BP gas station. All models control for station fixed effects. Standard errors are clustered by station. Significance at 1%**, 5%*.

TABLE 3: OIL SPILL IMPACT AND REID VAPOR PRESSURE REGULATION

VARIABLE	Average Net Price	Ln(Ave. Fleet Sales)	Weekly Net Price	Ln(Weekly Fleet Sales)
	(1)	(2)	(3)	(4)
During-spill	0.075**	0.011	0.075**	0.024**
	(0.003)	(0.009)	(0.002)	(0.007)
Post-spill	-0.076**	-0.040**	-0.076**	-0.038**
	(0.001)	(0.011)	(0.001)	(0.009)
BP*During-spill	-0.075**	-0.023	-0.075**	-0.027
	(0.004)	(0.020)	(0.003)	(0.017)
BP*Post-spill	0.020**	-0.039	0.021**	-0.038
	(0.003)	(0.024)	(0.002)	(0.020)
Observations	6,010	5,350	211,285	190,283
Adjusted R-squared	0.886	0.958	0.645	0.849
Fixed Effects	Station	Station	Station	Station
S.E.cluster	Station	Station	Station	Station
Weight	price observation	quantity observation	price observation	quantity observation
# stations	2,122	1,871	2,122	1,871

Notes: Source: OPIS. The sample covers the period from January 2009 to March 2011. Sample restricted to states meeting the standard summertime Reid Vapor Pressure (RVP) 9.0 psi limit. The coefficients reported are from regressions of BP retail price and log-quantity on the during-spill dummy, the dummy for post-spill period, and their interactions with a dummy for BP gas station. Columns (1) and (2) report estimates where the dependent variable is the station's average net price and average log-quantity computed over the entire "pre-," "during-," and "post-" spill periods. Columns (3) and (4) report estimates where the dependent variable is the individual station's weekly net price and log-quantity. All models control for station fixed effects. Standard errors are clustered by station. Significance at 1%**, 5%*.

TABLE 4: IMPACT OF OIL SPILL AS A FUNCTION OF GREEN PREFERENCES

	(1)	(2)	(3)	(4)	(5)	(6)
DEP. VARIABLE:	Price Diff	Sales Diff	Price Diff	Sales Diff	Price Diff	Sales Diff
BP	-0.043**	-0.036**	-0.041**	-0.036**	-0.041**	-0.033**
	(0.002)	(0.009)	(0.002)	(0.010)	(0.003)	(0.010)
Pct hybrid, Demeaned			0.008**	-0.003		
			(0.002)	(0.009)		
BP*(Pct hybrid, Demeaned)			-0.012*	0.039		
			(0.005)	(0.021)		
Income, Demeaned			-0.000	0.000	-0.000	0.000
			(0.000)	(0.000)	(0.000)	(0.000)
BP*(Income, Demeaned)			0.001**	-0.002*	0.001**	-0.001
			(0.000)	(0.001)	(0.000)	(0.001)
Green Index					0.006**	-0.002
					(0.001)	(0.002)
BP*(Green Index)					-0.006**	0.013
					(0.002)	(0.008)
Constant	0.073**	0.016**	0.073**	0.017**	0.074**	0.016**
	(0.001)	(0.004)	(0.001)	(0.004)	(0.001)	(0.004)
Observations	6,388	5,868	6,388	5,868	6,388	5,868
Adjusted R-squared	0.050	0.002	0.057	0.003	0.070	0.002
# stations	6,388	5,868	6,388	5,868	6,388	5,868

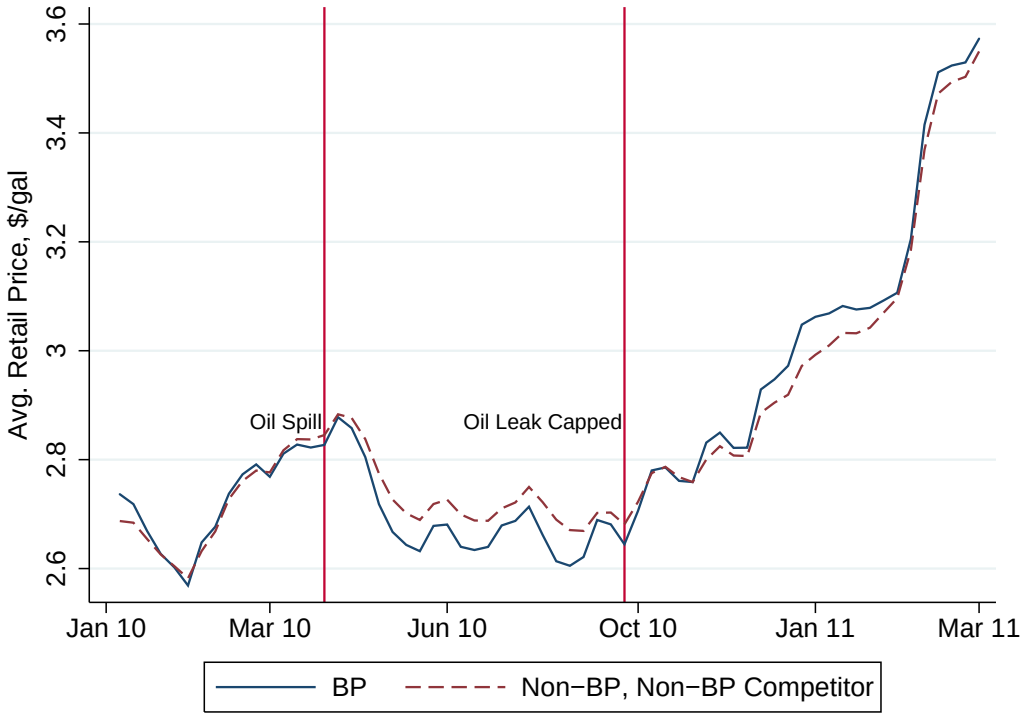
Notes: Sources: OPIS, Sierra Club, the U.S. Green Building Council, the U.S. Census and Kantar Media. The sample is restricted to stations with available data on Green Index and household income. Columns (1) and (2) report the benchmark estimates from Table 1 for the sample of stations that has income, green index, and hybrid car share data available. The dependent variable is the station's price difference or log-quantity difference between the "pre" and "during" spill periods. Columns (3) and (4) add median household income and hybrid vehicle shares as control variables. Columns (5) and (6) add income and the Green Index. The Green Index is the sum of z scores for four variables: the hybrid share of vehicle registrations at the zip-code level in 2007, Sierra Club membership, the number of LEED-registered buildings per capita, and contributions to Green Party committees. Zip-code income is in 2000 U.S. $thousands. Significance at 1%**, 5%*.

TABLE 5: OLS AND IV ESTIMATES OF OIL SPILL IMPACT INCLUDING INTERACTIONS WITH GREEN PREFERENCES AND PRE-SPILL ADVERTISING

	OLS ESTIMATES		OLS ESTIMATES		2SLS ESTIMATES	
DEPENDENT VARIABLE:	Price Diff	Sales Diff	Price Diff	Sales Diff	Price Diff	Sales Diff
	(1)	(2)	(3)	(4)	(5)	(6)
BP	-0.035**	-0.031**	-0.042**	-0.029*	-0.044**	-0.025*
	(0.002)	(0.010)	(0.003)	(0.011)	(0.003)	(0.012)
Green Index			0.006**	-0.001	0.005**	-0.002
			(0.001)	(0.003)	(0.001)	(0.003)
BP*(Green Index)			-0.007**	0.010	-0.007**	0.010
			(0.002)	(0.008)	(0.002)	(0.009)
Income, Demeaned			0.000	0.000	0.000	0.000
			(0.000)	(0.000)	(0.000)	(0.000)
BP*(Income, Demeaned)			0.001**	-0.002*	0.000*	-0.002*
			(0.000)	(0.001)	(0.000)	(0.001)
Ad spending, Demeaned			-0.000	0.000	-0.001**	-0.000
			(0.000)	(0.001)	(0.000)	(0.001)
BP*(Ad spending, Demeaned)			0.003**	0.000	0.004**	-0.001
			(0.000)	(0.002)	(0.001)	(0.002)
Constant	0.067**	0.013**	0.067**	0.013**	0.062**	0.014**
	(0.001)	(0.004)	(0.001)	(0.004)	(0.001)	(0.005)
# observations	5,088	4,662	5,088	4,662	5,002	4,582
# stations	5088	4662	5088	4662	5,002	4,582
R-squared	0.039	0.002	0.074	0.002	0.075	0.003

Notes: Source: OPIS, Sierra Club, R.L. Polk, the U.S. Green Building Council, and U.S. Census. The sample is restricted to stations with available data on Green Index, household income, and BP advertising expenditures. Columns (1) and (2) report the benchmark estimates from Table 1 for the stations that have income, Green Index, and advertising data available. The dependent variable is the station's price difference or log-quantity difference. Columns (3) and (4) report results with added controls for Green Index, demeaned median household income, and demeaned cumulative BP advertising expenditures during the 'Beyond Petroleum' campaign years for the BP Corporation, BP fuels, and environmental issues. Expenditures are in $millions, with mean $1.5 and std. $3.4 mil. The regressors of interests are the interactions of these variables with the BP gas station dummy. The price difference is the average net price in the during-spill period minus the pre-spill period. The log-quantity difference is the log average quantity in the during-spill period minus the pre-spill period. Columns (5) and (6) report 2SLS estimates instrumenting BP advertising expenditures with the DMA average spot TV ad price across all industries and products in 2007-2008. First stage results are in the Online Appendix. The Green Index is sum of z scores for four variables: the hybrid share of vehicle registrations at the zip-code level in 2007, Sierra Club membership, the number of LEED-registered buildings per capita, and contributions to Green Party committees. Zip-code income is in 2000 U.S. $thousands. Significance at 1%**, 5%*.

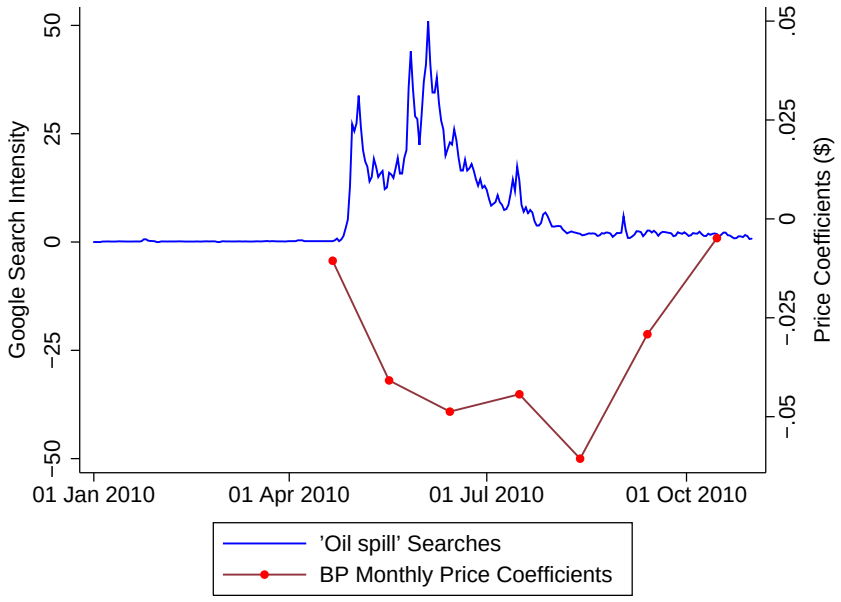
FIGURE 1
AVERAGE WEEKLY PRICE (LEVEL) FOR BP AND CONTROL STATIONS
JANUARY 2010 TO MARCH 2011



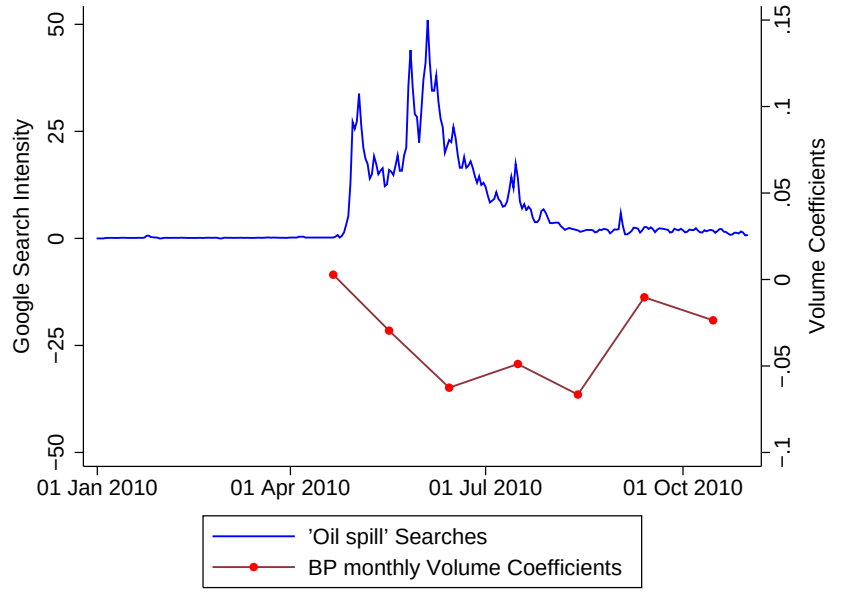
Notes: Source: OPIS. The figure displays average weekly prices for BP and non-BP competitor stations in our sample of 7,503 stores. See text and Online Appendix for details on our sample construction, and for a zoomed out version of the graph starting at the beginning of our sample in 2009.

FIGURE 2: GOOGLE SEARCH INTENSITY OF BP OIL SPILL RELATED SEARCHES

Panel A. Google Intensity and Price Coefficients



Panel B. Panel A. Google Intensity and Quantity Coefficients



Notes: Source: OPIS and Google Insights (accessed 8/16/2011). The figures display in blue the Google search intensity for the phrase "oil spill" relative to January 2004. For a given month, the Google search intensity measures the ratio of searches in that month to searches during the baseline month. A value of 50 thus indicates that searches in a month were 50 times greater than in January 2004. The red lines with markers plot the month-specific coefficients presented in Table 2. The dependent variables are station weekly net prices and log-quantity, respectively. Each dependent variable is regressed on post-spill month dummies and their interactions with a dummy for BP gas station. All models control for station fixed effects.

FIGURE 3A: BP MARKET SHARE TIME-DUMMY COEFFICIENTS, ABOVE MEDIAN ADVERTISING SPENDING

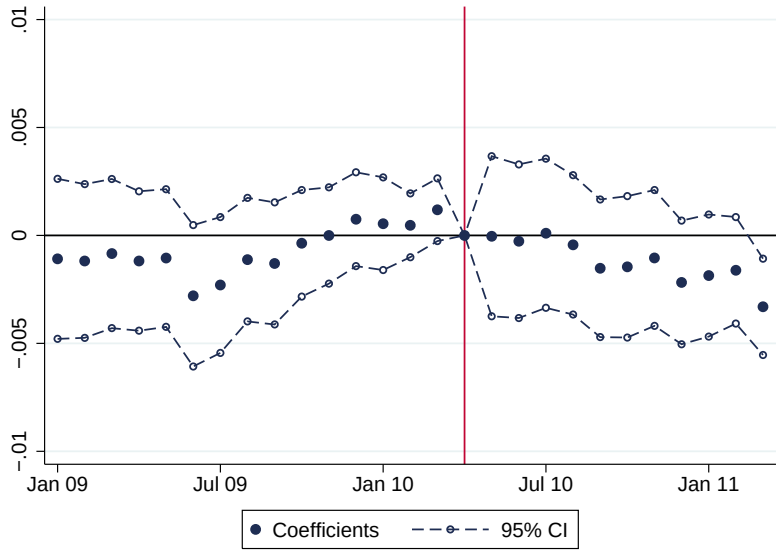
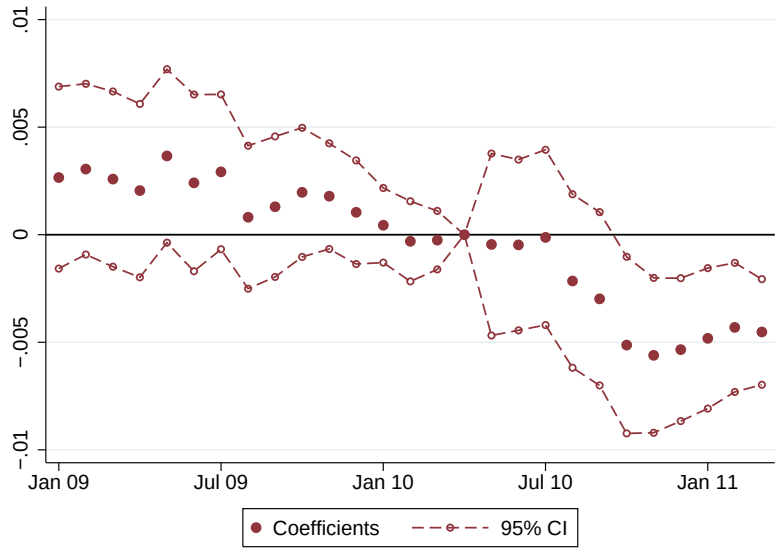


FIGURE 3B: BP MARKET SHARE TIME-DUMMY COEFFICIENTS, BELOW MEDIAN ADVERTISING SPENDING



Notes: Sources: OPIS and Kantar Ad$pender. This figure displays the coefficients on monthly time dummies –relative to the omitted April 2010 oil spill month – from a regression of the share of BP stations in each zip code-month on these time dummies as well as zip code fixed-effects (see specification (3) from the text). The regression was estimated separately for zip codes in metro areas with above and below median BP ad spending during the Beyond Petroleum campaign years of 2000-2008. The corresponding regression results can be found in the Online Appendix.