Journal of the Academy of Marketing Science (2019) 47:702–722
https://doi.org/10.1007/s11747-018-0611-8

ORIGINAL EMPIRICAL RESEARCH

Promotions as competitive reactions to recalls and their consequences

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Received: 9 February 2018 / Accepted: 27 September 2018 / Published online: 11 October 2018

Abstract

Firms may profit from responding to competitors' product recalls, but relatively little is known about the nature and efficacy of these reactions. The authors empirically (1) test the link between a major recall (by Toyota) in the automobile context and competitors' promotional responses and (2) assess the effectiveness of promotional responses and how it varies across brand tiers. They find that though Toyota recalls induced competitive promotions of approximately $850 on average, the competitive promotional reactions did not significantly affect sales on average. However, the results differ substantially by brand tiers. While 50% of premium brands increased promotions, only 36% of nonpremium brands did so. Among premium brands, 86% benefited from promotional reactions; in contrast, the effects of promotions on sales were nonsignificant or even negative for most nonpremium brands. These findings suggest that well-established results on promotional behaviors and their effectiveness may not hold in the context of recalls.

Keywords Product recalls · Competitive reactions · Promotions · Quasi experiments

When firms issue product recalls and publicly admit to product defects, they harm consumer perceptions of their products and suffer reputational and financial losses (e.g., Rhee and Haunschild 2006; Van Heerde et al. 2007). For example, drug giant Merck estimated a $2.5 billion revenue reduction due to the 2004 recall of Vioxx, which was proved to raise the risk of heart attacks and strokes for patients taking it over long periods (Appleby and Krantz 2004).[1] Major product recalls, by nature, represent a *negative shock to the perceived quality* of a key player in the category.

In such a scenario, how do *other firms* in the industry change their promotional strategies to derive strategic benefit from the competitor's negative quality shock? Should firms aggressively promote their products to increase differentiation (Goldfarb et al. 2009) and attract demand from the firm facing the recall? Or should firms reduce promotions lest they be perceived as ambulance chasers (Cleeren et al. 2013) or as providers of low-quality products (Raghubir and Corfman 1999)? The lack of clear answers has led to abundant but conflicting expert advice (e.g., Boomer 2014; Reputation Lighthouse 2017), media reports (e.g., KelloggInsight 2008; Woo 2007), and popular press articles (e.g., Lancaster 2010; Singer and Abelson 2011). Surprisingly, this critical issue has not garnered rigorous empirical scrutiny.

Marnik Dekimpe served as Area Editor for this article.

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11747-018-0611-8) contains supplementary material, which is available to authorized users.

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[1] Mattel, the leading toy manufacturer in the United States, recalled more than 19.6 million products in 2007 because of design flaws and lead-based paint (Thottam 2007), incurring significant financial losses (Story and Barboza 2007). The massive "unintended acceleration" recalls of Toyota and Lexus vehicles in 2009 and 2010 led to a more than 20% drop in Toyota's stock price in just over a month (Brauer 2014), approximately $2 billion in costs to fix affected vehicles, and lower sales and reduced value of leased vehicles (Isidore 2010).

Prior research on product recalls and brand crises (see Table 1 and Table W1 in Web Appendix A for an overview, and the next section for a detailed discussion) explores consequences to the firm issuing the recall (e.g., Chen et al. 2009; Van Heerde et al. 2007) or to the entire category (e.g., Borah and Tellis 2016; Cleeren et al. 2013), without explicitly studying how competitors react. The only study that has considered the effects of promotions after a recall (i.e., Cleeren et al. 2013) does not separate competitive reactions from programmatic promotions. The only study that considers competitive reactions (Rubel et al. 2011) focuses on anticipated rather than actual advertising reactions. However, unlike competitive advertising, promotions can signal low quality for some brands and thus may have unexpected effects in the context of recalls because major recalls tend to draw public attention to product quality. It follows that the available theoretical results cannot directly be used to predict the consequences of promotional competitive reactions during major recalls. Product recalls thus provide unique opportunities and challenges to competing firms but, despite a rich prior literature on product recalls, we have limited knowledge to guide promotional responses to the recalls of competitors.

Our study fills this gap in the recall literature by (1) providing empirical evidence of firms' promotional reactions to a competitor's major recalls, (2) examining how promotional reactions affect firms' postrecall sales, and (3) exploring how promotional reactions and their effectiveness differ across brand tiers. Thus, we provide a lens through which to unveil research and managerial implications of *competitive reactions to major recalls*.

We use the 2009–2010 Toyota recalls as the research context. We regard the Toyota recall event as an industry shock and use a quasi-experimental approach to analyze the impact of the product recall on other firms' promotional reactions.[2] Subsequently, we assess the impact of firms' promotional reactions on their postrecall sales, using an instrumental variable approach to address the potential endogeneity of promotional reactions. We find that though Toyota recalls increased competitive promotions in the categories of the recalled products by an average of approximately $850 (3%), these competitive promotional reactions did not significantly affect sales on average. However, the results differ substantially for premium and nonpremium brands. While 50% of premium brands significantly increased promotions, only 36% of nonpremium brands did so. Among premium brands, 86% benefited from promotional reactions in the form of increased sales; however, only 9% of nonpremium brands benefited from promotional reactions, and the effectiveness of promotion on sales was nonsignificant or even negative for most nonpremium brands.

With this research we contribute to the marketing literature on product recall and brand crisis in three ways. First, we provide the first empirical (causal) evidence of firms' promotional reactions to *competitors' product recalls*. Previous work on product recalls or brand crises has mostly focused on understanding the consequences of product recalls or brand crises (e.g., Borah and Tellis 2016; Chen et al. 2009), rather than firms' marketing reactions. For managers in the automobile industry, this finding means that they could have anticipated their competitors to discount their products by about $850 per unit on average after Toyota's recalls.

Second, we show that premium brands were more likely than nonpremium to promote after Toyota's recalls. This finding adds to the literature, because previous work suggests that under normal conditions premium brands are unlikely to promote because of fear to harm their equity (Heil and Helsen 2001). Our findings show that Toyota's major recalls created a boundary condition, in which firms could deviate from their normal promotional strategies. For managers of premium automobile brands this finding means that they could have anticipated a $2000–$3000 per unit discount on some competing products after Toyota's recalls.

Third, our research enriches the literature on product recall and brand crisis by showing that premium brands may benefit more from competitive promotional response to recalls than nonpremium brands. This finding contributes to the literature because previous literature does not provide insights on the effectiveness of marketing reactions to a competitor's recall or on how the effectiveness may be heterogeneous across brand tiers. Our research shows that, immediately after a major recall, promotional responses can hurt postrecall sales of brands with low perceived quality. For managers of most nonpremium automobile brands, the results mean that not reacting to Toyota's recalls with promotions could have prevented harming sales and could have even increased them. For managers of most premium automobile brands, the results mean that promotional increase after Toyota's recalls could have substantially increased sales.

We organize the rest of the article as follows. We first propose a theoretical framework to summarize the relevant literature and then we describe the institutional background, the data, and empirical setting. This is followed by a description of our two-stage estimation methodology, the results, and robustness tests. We conclude with a general discussion, managerial implications, and limitations.

Theoretical framework

In what follows we describe the effects of product recalls on perceived quality and then elaborate on how they affect the

[2] The treatment group consists of non-Toyota car models in the same categories as car models recalled by Toyota. We then match each treatment car model to a control car model in a different category, based on manufacturer and brand tier, attributes, and manufacturer suggested retail price. Details are discussed later.

Table 1 Recall literature review

Study	Results	Marketing instrument	Recall Impact on	Research Method	Empirical Context	Competitive reactions	Endogeneity Correction	Brand Tier Asymmetry
Van Heerde et al. (2007)	Product recalls lead to decreased sales and reduced effectiveness of marketing instruments	Advertising and price	Focal firm	Empirical (time series models)	Kraft peanut butter, Australia	No	No	No
Gao et al. (2015)	Prerecall advertising spending moderate the financial damage of recalls	Advertising	Focal firm	Empirical (event study)	Automobile industry	No	Yes	No
Marsh et al. (2004)	Meat product recalls deflate category demand for meat and increase demand for nonmeat substitutes	None	Focal category	Empirical (expenditure system)	Food industry	No	No	No
Freedman et al. (2012)	Manufacturers that did not experience any recalls also saw significant sales losses	None	Competitors	Empirical (regression)	Toy industry	No	No	No
Cleeren et al. (2013)	Recalls hurt category sales when the firm issuing the recall publicly acknowledges blame	Advertising and price	Focal category	Empirical (panel data methods)	Household-scanner panels	No	Yes	No
Borah and Tellis (2016)	Negative word of mouth spills over to competing brands within the category, deflating competitor sales and stock market performance	None	Competitors	Empirical (time series analysis)	Four car brands in the automobile industry	No	Yes	No
Rubel et al. (2011)	When firms anticipate a recall, their optimal prerecall (postrecall) advertising decreases (increases); it is optimal for competitors to increase advertising	Advertising	Focal firm + Competitors	Analytical + Empirical (state space models)	Three car models in the automobile industry	Anticipated	No	No
Bala et al. (2017)	The focal firm's optimal sales effort allocation strategy depends on (dis)economies of scope across categories and recall probability	Sales effort	Competitors	Analytical	NA	Anticipated	NA	No
Present Study	Firms reacted to Toyota recalls by increasing promotions, however, the effectiveness of promotional reactions on postrecall sales is asymmetric across brand tiers	Promotion	Competitors	Empirical (quasi-experiments)	Car models of all categories in the automobile industry	Actual	Yes	Yes

performance of brands and firms in the category of the recalled products. We make predictions on how a firm (*the focal firm*) may use promotions to react to the recalls of a competitor (*the recall firm*) and on how effective these reactions may be. Finally, given the special role of perceived quality, we hypothesize how focal firm behavior and performance during a competitors' recall may depend on the brand tier of the products it offers. Noting that major recalls are often associated with brand crises (e.g., Cleeren et al. 2008; Dawar and Pillutla 2000), we base our theoretical development on existing results from both literatures on recalls and brand crises. While our focus is on the observational study of promotional strategies and studies on brand crises focus more on the experimental analysis of communication strategies, promotions can be used to respond to the negative consequences of brand crises other than those caused by major recalls.[3] Table 1 and Table W1 in Web Appendix A illustrate how this study differs in terms of contribution and approach from extant work in the literatures on recalls and brand crises, respectively.

Vertical quality and product recalls

Product safety plays a major role in product recalls because product recalls are issued in response to safety concerns. Hence, consumers may interpret major product recalls as signals of low product safety. Because perceived safety is a major component of perceived product quality (Tse 1999), product recalls may also affect consumer perceptions of product, brand, and firm quality (e.g., Thirumalai and Sinha 2011; Van Heerde et al. 2007). In particular, product recalls may affect perceived vertical quality but not perceived horizontal quality. The distinction between vertical and horizontal quality arises because there are product attributes for which consumers have homogeneous preferences (e.g., safety) and products for which they have heterogeneous preferences (e.g., color) (Golder et al. 2012). We define the vertical quality of a good by the level of its combined attributes associated with homogeneous preferences. We associate premium brands with high vertical quality and nonpremium brands with low vertical quality because perceived safety positively correlates with price (Tse 1999).

Impacts of product recalls

As the representative studies listed in Table 1 suggest, the decrease of perceived vertical quality induced by major product recalls leads to other negative consequences on the recalled product, its brand, and its manufacturer, including lowered reputation and customer loyalty (Hendricks and Singhal 2001; Thirumalai and Sinha 2011), damaged brand equity, lowered advertising effectiveness, and poorer market confidence of investment (Chen et al. 2009; Gao et al. 2015; Laufer and Coombs 2006; Rhee and Haunschild 2006; Siomkos and Kurzbard 1994; Van Heerde et al. 2007).[4]

Furthermore, some of the studies summarized in Table 1 show that one firm's product recall may affect the entire product category negatively. Product recalls deflate category demand and increase demand for substitute categories (Marsh et al. 2004), affecting manufacturers who do not experience any recalls (Freedman et al. 2012). Such spillovers of recalls within entire categories may take place through negative word of mouth and affect not only sales but also stock market performance (Borah and Tellis 2016). In the broader context of brand crises (see Table W1 in Web Appendix A), Roehm and Tybout (2006) show that entire categories are affected because a scandal of a typical brand in the category negatively affects consumer perceptions of the focal category. Zou and Li (2016) find that competitors of a brand that suffers a crisis experience negative abnormal returns.

This stream of literature does not study competitive reactions to recalls and thus does not provide guidance on how firms should use promotions to respond to the recalls of competitors, which is the focus of this paper.

Reactions of firms to own recalls

As shown in Table 1, the evidence on the effectiveness of different reactions to own recalls is fragmented. Cleeren et al. (2013) analyze fast-moving consumer goods recalls and find that publicly acknowledging blame for a recall may propagate the negative consequences of the recall and hurt category sales, because competitors in the same category may be perceived as guilty by association. Gao et al. (2015) suggest that prerecall advertising spending can be used as a tool to moderate the financial damage of recalls. In particular, firms may mitigate the negative effects of anticipated recalls by decreasing (increasing) advertising before (after) the recall (Rubel et al. 2011).

While the above studies have shed light on the effectiveness of strategies to mitigate the negative effect of recalls and brand crises on the recall firm, they do not offer insights on reactions of the competitors and their effectiveness, which is the focus of present study. Furthermore, most of aforementioned studies focus on communication strategies, (see Table 1 and Table W1). Only Cleeren et al. (2013) consider the effects of promotions after a recall. However, their study does not separate competitive reactions from programmatic promotions.

[3] Firms can also react to recalls through advertising strategies. Regrettably, we cannot study such advertising reactions in our institutional context because the advertising data are too sparse and treatment and control groups are not comparable.

[4] A few studies show that negative repercussions are not universal (Berger et al. 2010; Kalaignanam et al. 2013), even though they might be the norm.

Reactions of firms to competitors' recalls

Table 1 summarizes two studies in which theoretical models are proposed to derive the optimal advertising and sales efforts when a firm anticipates a future recall. Rubel et al. (2011) conclude that it is optimal for competitors to increase advertising to take advantage of the expected sales loss of the firm issuing the recall. Bala et al. (2017) derive optimal sales effort allocation strategies of competitors across multiple product categories when anticipating a recall in one category. As listed in Table W1, in the context of brand crises, Zou and Li (2016) find that advertising strengthens the spillovers of a crisis, but charity donation and product diversity of competing firms weaken them. Roehm and Tybout (2006) show that the negative spillovers of a recall can also be mitigated by priming consumers to think about differentiation among brands. None of these studies, however, empirically characterize actual reactions of competitors to recalls; neither they consider promotions.

Regarding promotions, research unrelated to product recalls or brand crises suggests that, when the perceived quality of a leading brand decreases, the market becomes less differentiated (Goldfarb et al. 2009). Competitors should then promote their products to preserve differentiation. Because product recalls lower quality perceptions of the recall products, consumer preferences for the brand may weaken, making loyal consumers more willing to consider products of competing firms. This provides an opportunity for competing firms to strengthen their brand awareness and gain market share (Naik et al. 2008, 2005), which could be facilitated by increasing promotions (Blattberg and Neslin 1990). This argument implies that it may be wise for a focal firm to respond with a promotion to draw market share.

However, the sparse empirical research on competitive responses to recalls suggests that promotions may be perceived unfavorably by consumers during major recalls. In particular, increased promotion following a competitor's recall may not be perceived as ethical by consumers, leading to unfavorable attitudes and lower demand for the promoting firm (Cleeren et al. 2013). Furthermore, recalls raise public concerns about the quality of the recalled products, which may make safety (and thus vertical quality) more salient in consumers' choices. Previous research has also shown that when consumers use price promotions to infer product quality or value, they may avoid promoted products because they may perceive promotions as signals of low quality (Raghubir and Corfman 1999; Simonson et al. 1994).

It follows then that the effects of promotional reactions to a recall may systematically differ from the effects of programmatic promotions. However, because previous work has not empirically isolated actual promotional reactions to recalls from everyday promotional spending, the effects of such reactions are still unknown. It is thus not clear whether it is beneficial for a firm to increase or decrease its promotion as a reaction to a competitor's recall. We add to the recall and brand crises literatures by offering the first quasi-experimental evidence of a causal effect of a major competitor's recall on firms' promotional reactions and of the effectiveness of such reactions.

Heterogeneity in competitive promotional response to product recalls

Prior literature (summarized in Web Appendix A, Table W1) suggests that the effects of brand crises on competitors are moderated by consumer commitment towards a brand (Ahluwalia et al. 2000), consumer prior expectations on the firm (Dawar and Pillutla 2000), and brand similarity (Dahlen and Lange 2006; Roehm and Tybout 2006). Because perceived vertical quality is central to the study of brand crises associated with product recalls, we focus on the moderating effect of vertical quality instead of other variables such as consumer commitment, expectations, and brand similarity.

Prior research on promotions has explored both (1) how consumers react differently to promotions depending on the vertical quality of the promoting brands and (2) how the vertical quality of brands determines their likelihood of responding to competitors' promotions. In particular, previous studies suggest that consumer response to promotions differ across premium and nonpremium brands (e.g., Allenby and Rossi 1991; Blattberg et al. 1995; Pauwels 2007). Premium brands enjoy greater benefits from promotions, by attracting demand from both competing premium brands and nonpremium brands (Blattberg and Wisniewski 1989; Sivakumar and Raj 1997). Nonetheless, premium brands are not likely to offer large discounts (Heil and Helsen 2001) because promotions may harm brand equity and, in turn, price premiums (Blattberg et al. 1995; Sriram and Kalwani 2007). None of these studies, however, have considered the context of recalls and thus it is not clear whether their findings may hold in situations where the perceived quality of products is affected by recalls.

Under normal circumstances, consumers who usually prefer nonpremium brands may be more price sensitive and less willing to pay for safety than consumers who normally prefer premium brands (price is positively correlated with perceived safety; Tse 1999). In the event of a recall, however, safety may become more salient to consumers (including those who normally prefer nonpremium brands) and their preferences for vertical quality may become stronger. Unlike nonpremium brands, premium brands can capitalize on these heightened preferences by making their products more affordable to consumers who normally prefer nonpremium brands. The benefits of promoting after a competitor's recall thus loom larger for premium brands. Moreover, the potential negative effects

of promotional reactions, such as seeming opportunistic (Cleeren et al. 2013) and signaling low quality (Raghubir and Corfman 1999; Simonson et al. 1994) may be smaller for premium brands, because of their stronger brand equity and higher perceived vertical quality. Because these increased returns and diminished risks may be expected only by premium brands, such brands are more likely than nonpremium brands to promote after a competitor's recall. We likewise expect premium brands to benefit from such promotions more than nonpremium brands.

Because the recall and brand crises literatures have not explored the moderating role of vertical quality, we further contribute to these literatures by exploring how the causal effects of a competitor's major recall on firms' promotional reactions and the effectiveness of those reactions differ across competitors of different levels of vertical quality.

In summary, our theoretical framework suggests that promotional reactions to competitors' recalls may allow premium brands, but not nonpremium brands, to increase the sales of their products. As a result, we predict that (1) premium brands may be more likely than nonpremium brands to respond to a competitor's recall by increasing their promotions, and (2) premium brands may benefit from promotional reactions more than nonpremium brands. Next, we empirically test these assertions.

Institutional background, data, and research design

The 2009–2010 Toyota recall crisis

On August 28, 2009, a Lexus ES350 accelerated out of control on Highway 125 in Santee, California.[5] After hitting another car, it tumbled down an embankment and caught fire. All four people in the car were killed in the crash. A dramatic recording of the victims' emergency call during the car accident led the media to track other incidences of unintended acceleration of Toyota vehicles and also led the NHTSA (National Highway Traffic Safety Administration) to initiate safety investigations. Toyota did not publicly admit to defects in Toyota and Lexus vehicles until November 2, 2009, when the NHTSA publicly rebuked Toyota for denying the defects in rubber floor mats (the accelerator pedal jammed against it, causing unintentional acceleration). Subsequently, Toyota publicly apologized and issued a voluntary recall covering 4.2 million Toyota and Lexus vehicles. (We list the car models recalled by Toyota in November 2009 in Table W2 in Web Appendix B.) The crisis grew worse on December 26, 2009, when a Toyota Avalon crashed into a lake in Texas after accelerating out of control. As the floor mats had been removed from this vehicle, they were ruled out as the cause of the accident. Toyota announced that there were defects in the gas pedal that could lead to unintentional acceleration and recalled another 2.3 million vehicles on January 21, 2010.[6] The timeline of the crisis is thus as follows.

California incident, attributed to floor mats	➔ First recall, 4.2 M vehicles	➔ Texas incident, attributed to pedal	➔ Second recall, 2.3 M vehicles
08/28/2009	11/02/2009	12/26/2009	01/21/2010

Although the NHTSA can drive the issuance of product recalls, Toyota's product recalls were arguably a strategic reaction to limit extensive brand harm. Indeed, prior research suggests that product recalls can be strategically managed to limit financial loss (Ball et al. 2015; Chen et al. 2009). Recalls could be perceived as acts of ethical responsibility (Souiden and Pons 2009) and, in some cases, even serve as a source of publicity (Berger et al. 2010; Chen et al. 2009). Hence, the recall may represent a relatively controllable, negative shock to the perceived quality of Toyota products (made more credible by Toyota's own admission).

In contrast, for Toyota's competitors, the recall represents an *exogenous* shock because competing firms have no direct influence on the timing and magnitude of Toyota's recall. Therefore, from a competing firm's standpoint, Toyota's recall represents a *exogenous negative shock to the perceived quality* of one of the main players in the category.[7]

Sample and data

We collected data for car models of popular brands (accounting for 99% of total market sales) available in the United States market from 2000 to 2012. To avoid any bias from heightened promotions of new car models or car models soon to be discontinued, we investigated only car models produced and sold before, during, and after the observation window (i.e., 2009 and 2010). Furthermore, we excluded models produced by the manufacturer of the recalled models (specifically, Toyota, Lexus, Scion, and twin Pontiac models), given our focus on competitive reactions. Table 2, Panel A, presents the brands included in the analysis.

We obtained monthly promotional spending (i.e., effective dollar promotions per unit sold that dealers pass through to

[5] The content regarding the crisis comes from http://www.motortrend.com/features/auto_news/2010/112_1001_toyota_recall_crisis/viewall.html.

[6] In addition to floor mat and gas pedal defects, driver error was found to have contributed to the majority accidents from sudden acceleration of Toyota and Lexus vehicles (Mitchell et al. 2011). However, our analyses focus on the short-term impacts of this crisis, which occurred before the role of driver error was reported.

[7] It is arguable that the Toyota recall represents a negative quality shock to all the players in the category. Yet a review of the media reports during the crisis (e.g., Kelly 2012; Sawyers 2010) shows overwhelming reference to the negative quality of Toyota's cars, and Toyota's negligence, rather than the competitors.

Table 2 Data description

A: Car Brands in the Sample		
Brand Tier	Brand	
Premium	Acura, Audi, BMW, Cadillac, Infiniti, Jaguar, Land Rover, Lincoln, Mercedes-Benz, Porsche, Saab, Volvo	
Nonpremium	Buick, Chevrolet, Chrysler, Dodge, Ford, GMC, Honda, Hyundai, Jeep, Kia, Mazda, Mercury, Mini, Mitsubishi, Nissan, Saturn, Smart, Subaru, Suzuki, Volkswagen	
B: Variable Description		
Variables	Description	Source
Promotion	Average dollar incentives per unit sold of the focal car model in the focal year-month. Includes consumer rebates, discount financing, lease rate subvention, residual exposure, dealer allowances, volume bonus payments, and contests.	Autodata Corp.
Sales	Unit sales of the focal car model in the focal year-month	Autodata Corp.
Price	Manufacturer suggested retail price (MSRP) of the base trim of the focal car model in the focal year	WardsAuto
Advertising Stock	Cumulative advertising spending (in 1000 dollars) of the past three months, across all advertising channels, on the focal car model	Derived from TNS Media Intelligence (ad$pender)
Number of Dealers	Total number of dealers in United States of the focal make in the focal year	Automotive News
Safety	Overall safety rating derived from the outcomes of controlled frontal and side impact tests	National Highway Traffic Safety Administration
Updates	Indicator of whether a particular 2010 model underwent a change of platform (excluding minor engine changes and model facelifts)	Wikipedia and other expert sites
Avg. Promotion 2006–2008	Average promotions in the same month of 2006–2008 of the focal car model	Derived from Autodata Corp.
Avg. Sales 2006–2008	Average sales in the same month of 2006–2008 of the focal car model	Derived from Autodata Corp.

Source of brand tier classification data: J.D. Power

consumers) and unit sales data at the make-model level from AutoData Corp. We also collected car attribute variables (e.g., MPG [miles per gallon], horsepower), used to match car models in the treatment and control groups, from WardsAuto. The control variables include manufacturer suggested retail price (MSRP), advertising stock, size of dealer network, safety, and model updates. Detailed descriptions and sources of the key variables appear in Table 2, Panel B.

As discussed previously, Toyota publicly acknowledged the defects in some vehicles and initiated the first recall in November 2009 and the second recall in January 2010. To obtain a clean before/after comparison, we defined (1) the treatment period as the three-month period from November 2009 to January 2010, (2) the before-treatment period as the months before November 2009, and (3) the after-treatment period as the months after January 2010. Given that firms may have reacted quickly to the recalls, we used seven months before (April 2009–October 2009) and seven months after (February 2010–August 2010) as observation windows to construct the sample for promotional reactions. We conducted robustness tests with alternative observation windows to demonstrate that the results do not qualitatively change with different windows.

Definition of treatment group and control group

Car models differ in terms of manufacturer (e.g., Honda, Ford, Volkswagen), brand tier (e.g., premium, nonpremium), and model category (e.g., compact sedan, intermediate sedan, crossover-utility vehicle [CUV]). A car model was regarded as treated if *Toyota Motor Corporation* recalled any product in the category of that car model. The recalls occurred in both brand tiers (i.e., Toyota and Lexus), but only for models in a few categories (e.g., Toyota Camry in midsize conventional, Toyota Corolla in compact conventional). The treatment group consists of all non-Toyota car models in the categories of car models recalled by Toyota. For example, the key competitors in the nonpremium, compact sedan category are the Toyota Corolla, the Honda Civic, and the Ford Focus. Thus, because the Toyota Corolla was recalled, the Honda Civic and the Ford Focus were in the treatment group. We provide a list of all treated car models, specifying their categories and the sources of their treatment, in Table W3 of Web Appendix B. We expect promotion intensity of the car models in the treatment group (e.g., the Honda Accord) to change because of Toyota recalls (e.g., the recall of the Toyota Camry in the category of the Honda Accord).

We also needed a control group to benchmark the change in promotion intensity of cars in the treatment group. An ideal control group should (1) follow the same promotion strategies and cycles as the treatment group before Toyota recalls, and (2) not be affected by the recalls. We do not have the perfect control group due to the quasi-experimental nature of our study. Hence, we matched each treatment car model to the closest control car model chosen among the car models in categories in which Toyota car models were *not recalled*. We lay out the criteria with which we defined the control group as follows. First, we ensured that the control car model

is in a *different category.* Second, we ensured that the control car model is matched on *manufacturer and brand tier* to the treated car model. Third, we ensured that the control car model is matched on *attributes and MSRP* to the treated car model.

Table 3 provides two examples of how we followed three steps to construct the control group. In the first example, the Nissan Rogue is in the treatment group, and the Nissan Quest, which shares *manufacturer* (Nissan) and *brand tier* (nonpremium) with the Nissan Rogue but is in the *midsize van category rather than the compact CUV category*, belongs to the control group. Note also that the Nissan Rogue and the Nissan Quest have comparable attributes (e.g., horse power, MPG) and MSRPs. In the second example, the Kia Spectra is in the treatment group, and the Kia Rio, which shares *manufacturer* (Kia), *brand tier* (nonpremium), and similar attributes and MSRP with the Kia Spectra but is in the *compact basic category rather than the compact conventional category*, belongs to the control group.

To ensure robust matching on all the three criteria, we constructed the control group using the nearest-neighbor matching method and sampling with replacement from the pool of qualified car models. We used manufacturer and brand tier fixed effects, attributes, and MSRP as covariates of the logistic regression of the matching procedure. We provide a list of all treatment group car models and their corresponding control group models in Table W4 of Web Appendix B.

Table 3 Procedure for selection of control group

Step	Criteria	Procedure	Example 1: Nissan Rogue	Example 2: Kia Spectra
1	Control unit should not be affected by the recalls	Select car models from all categories where no cars were recalled	Select all cars in the following categories: Compact Basic, Compact MPV, Compact Sporty, Compact SUV, Midsize Sporty, Midsize SUV, Midsize Van, Compact Premium Conventional, Compact Premium CUV, Compact Premium Sporty, Compact Premium MPV, Midsize Premium CUV, Midsize Premium Sporty, Midsize Premium SUV, Large Premium SUV, Large Premium Sporty, Large Premium Pickup, Large Van.	Select all cars in the following categories: Compact Basic, Compact MPV, Compact Sporty, Compact SUV, Midsize Sporty, Midsize SUV, Midsize Van, Compact Premium Conventional, Compact Premium CUV, Compact Premium Sporty, Compact Premium MPV, Midsize Premium CUV, Midsize Premium Sporty, Midsize Premium SUV, Large Premium SUV, Large Premium Sporty, Large Premium Pickup, Large Van.
2	Control unit should undergo similar promotion strategies and market conditions as treated unit	Among cars selected in Step 1, select those of same *manufacturer and brand tier* as the treated car model	Select nonpremium vehicles in the categories Compact Basic, Compact MPV, Compact Sporty, Compact SUV, Midsize Sporty, Midsize SUV, Midsize Van, and Large Van that are manufactured by Nissan Motors	Select nonpremium vehicles in the categories Compact Basic, Compact MPV, Compact Sporty, Compact SUV, Midsize Sporty, Midsize SUV, Midsize Van, and Large Van that are manufactured by Kia Motors
3	Control unit should be as similar as possible to the treated unit	Among cars selected in Step 2, select the one that most closely matches the treated car in terms of *attributes and MSRP*	Nissan Quest is selected as the control unit for Nissan Rogue. Nissan Rogue: Compact CUV, MSRP $24,800, MPG 26/33, Horse Power 170, Height/ Width 0.921, Antilock Brakes 4 Wheels Nissan Quest: Midsize Van, MSRP $27,540, MPG 20/27, Horse Power 260, Height/Width 0.926, Antilock Brakes 4 Wheels	Kia Rio is selected as the control unit for Kia Spectra. Kia Spectra: Compact Conventional, MSRP $16,700, MPG 24/32, Horse Power 138, Height/ Width 0.848 Kia Rio: Compact Basic, MSRP $13,900, MPG 29/37, Horse Power 130, Height/ Width 0.838

Estimation methodology

First stage: Estimating promotional reactions to Toyota recalls

Model description We observe promotion levels for car models in the treatment and control groups, both seven months before and seven months after Toyota's recalls of select car models. We use a difference-in-differences approach and compare the promotion differential (posttreatment promotion – pretreatment promotion) between car models in the treatment group and car models in the control group. Thus, we specify the promotion of car model i at month t as

$$Promotion_{it} = \alpha_p + \beta_{1p} Treatment_i + \beta_{2p} PostRecall_t + \beta_{3p} Treatment_i \times PostRecall_t + Make_{pi} + \theta_p' PromoControl_{it} + \epsilon_{pit}, \quad (1)$$

where α_p is the intercept, β_{1p} measures the average promotion difference between the car models in the treatment group and those in the control group, β_{2p} measures the average promotion changes of all car models after the Toyota recalls, and β_{3p} captures the incremental change in promotions of car models in the treatment group after the Toyota recalls relative to the control group (the effect of interest). Moreover, we include the fixed effect of the make of model i, $Make_{pi}$, and $PromoControl_{it}$, which is a vector of control variables (with θ_p being the

corresponding coefficient vector) capturing car model average promotions and sales in the same month of 2006–2008, the advertising stock (over the past three months) of the focal car model, the number of dealers of the focal make, the safety rating of the focal car model, and the degree of updates of the focal car model from 2009 to 2010. The average promotions and sales in the same month of 2006–2008 not only control for the possibility that firms adjust promotions using the past promotion and sales records of the same season but also control for the promotion differences (in dollars) caused by the retail price differences (i.e., more expensive cars command larger margins and can offer deeper discounts). The advertising stock, the number of dealers, the safety rating, and the degree of updates control for the potential impact on promotions of advertising spending, the size of distribution network, objective safety measures, and technological innovation. In addition, we cluster standard errors by car-model over time.

Identification Identification of the treatment effect is based on the satisfaction of the *SUTVA* (stable unit treatment value) assumption (Imbens and Rubin 2009), which involves three critical conditions.

> *SUTVA 1*: if no treatment occurred, the average promotion level would be homogeneous between treatment and control groups.

Manufacturers strategically decide promotion calendars in advance of the operating year, according to the following key drivers (DeAngelis 2010; Deep 1999):

a. Seasonality: Promotions are higher at the end of a quarter or calendar year, to offer dealers bonus-based incentives for meeting quarterly or yearly sales quotas (DeAngelis 2010; DeMuro 2016).
b. New product introductions: Car manufacturers introduce discounts on old car models when new car models are impending (e.g., model update), to clear the stock of old cars before the new car models arrive (DeAngelis 2010; DeMuro 2015).
c. Profit margins: Car manufacturers provide larger discounts on car models with greater profit margins, and profit margins vary by manufacturers, brand tier, and attributes (e.g., Deep 1999; Kallstrom 2015). For example, Japanese car manufacturers generally have higher margins than U.S. manufacturers (Kallstrom 2015), the profit margins of Infiniti car models are much higher than those of Nissan models,[8] and SUVs and pickup trucks generally have higher profit margins than small sedans (Deep 1999; Kwak 2009; Sudhir 2001).

[8] See http://www.swadeology.com/2014/02/how-do-car-companies-make-money/.

In our sample, we match car models in the treatment and control groups by manufacturer and brand tier; thus, seasonality in the promotion cycles should be homogeneous across both groups. Moreover, because we match car models by manufacturer, brand tier, attributes, and MSRP, we condition out the influence of brand (make) preferences and profit margins on the promotion intensity in the control and treatment groups. These arguments are supported empirically. We conduct auxiliary regressions using the pretreatment periods of our matched sample. We find that month, manufacturer-brand tier, and category fixed effects explain 61% of the variation in promotion, while car model fixed effects explain only 11% of the variation. This suggests that time of the year, manufacturer, brand tier, and category tend to be the major drivers of promotions.

> *SUTVA 2*: The treatment level is consistent across all car models.

In the automobile industry, competition occurs primarily *within car category* (Albuquerque and Bronnenberg 2012). For example, potential buyers interested in a midsize conventional car likely consider the Toyota Camry, the Honda Accord, the Nissan Altima, the Ford Fusion, the Chevy Malibu, and other car models in that category. The recall of the Toyota Camry hurts its quality perception (Sawyers 2010) and thus provides unique challenges and opportunities for all competing car models in the category of midsize conventional cars. From the perspective of competing car models, each observes the same negative quality shock to the same major competitor and therefore perceives similar challenges and opportunities, which may lead its manufacturer to react by adjusting promotions. In the case of Toyota recalls, many manufacturers (e.g., General Motors [GM], Chrysler, Hyundai) viewed the recall incidence as an opportunity to gain market share (Valdes-Dapena 2010). In summary, there should be no hidden variation in the perceived opportunities associated with the treatment across the treated car models.

> *SUTVA 3*: There is no interference between the treatment units and control units.

While promotion calendars are typically set based on the key drivers described in SUTVA 1, they may also be affected by *unexpected changes* in *category-level* competitive behaviors. Car manufacturers keep track of quality shocks, innovations, and discounts of competitors and may react by changing the promotion of car models in the category of the vehicles where the events take place (Niedermeyer 2011; Tuttle 2013). For example, in early 2013 Toyota provided cash-back incentives specifically for Toyota Prius after Nissan introduced a cheaper trim of Nissan Leaf, a direct competitor of Prius, at a competitive price (Tuttle 2013).

In our sample, firms with car models in the treatment group confront a shock to the perceived quality of a competitor's car in the same category. Thus, we would expect the treatment group to change its promotion intensity because of this event. In our research context, the recall was a negative quality shock to some Toyota models, such as the Toyota Camry, the Toyota FJ Cruiser, and the Toyota Highlander. However, other Toyota car models that were not recalled did not experience such a quality shock, as they were not made of the flawed parts and their owners did not need to have their vehicles fixed to avoid potentially fatal accidents. Consequently, competing car manufacturers should provide deep discounts only for relevant car models, (e.g., the Honda Accord, the Honda Pilot), as a response to the negative quality shock. Conversely, competing car manufacturers generally do not respond to unanticipated changes in other categories (i.e., the control group should be unaffected by the unanticipated quality shock in the treatment group).[9] The promotional response strategy detailed above can be rationalized by the car purchase process of most consumers. More specifically, when purchasing new cars consumers tend to first decide the type of vehicles they want, with attributes that satisfy their needs and prices that fit their budgets, and then compare similar vehicles of different brands to make the final purchase decision (Montoya 2016; Wardlaw 2016). This is consistent with the finding that substitution among car models within a category is stronger than substitution among car models within a brand (Albuquerque and Bronnenberg 2012).

As supporting evidence (available from authors upon request), we find that when controlling for the effect of promotional calendar, the changes in promotions of car models belonging to other categories of the same manufacturer do not strongly correlate. For example, the unexpected promotion change (i.e., after removing the impacts of MSRP, brand, time, and brand–time trend on promotion) of the focal car model in the prerecall period (2009) is not significantly influenced by the average unexpected changes in promotions of other car models of the same brand.

Heterogeneity in treatment effects Previous research suggests that products with different brand tiers follow different marketing strategies (Heil and Helsen 2001; Yamawaki 2002). We explore how promotional reactions to Toyota recalls differ across manufacturers and brand tiers. More specifically, we specify the promotion of model i at month t as

$$\begin{aligned} Promotion_{it} = {} & \alpha_p + \beta_{1p} Treatment_i + \beta_{2p} PostRecall_t + \beta_{3p} Treatment_i \times \\ & PostRecall_t + \beta_{4p} Treatment_i \times PostRecall_t \\ & \times ManufactPrem_i + \theta_p{}' PromoControl_{it} + \epsilon_{pit}, \end{aligned} \quad (2)$$

where variables and coefficients are defined consistently with Equation 1, except that $ManufactPrem_i$ is the indicator variable for the manufacturer-brand tier (e.g., GM-nonpremium, GM-premium) of the focal car model and β_{4p} measures the treatment effect on the focal manufacturer-brand tier in addition to the baseline (i.e., β_{3p}).

Second stage: Estimating the effectiveness of promotional reactions on sales

Model description In the first-stage estimation, our goal was to understand how recalls of some Toyota car models affect the promotion intensity of competing car models in the same categories. In the second-stage estimation, our goal is to assess the impact of these promotional reactions on their sales. Thus, our dependent variable in the second stage is the postrecall sales of competing car models, and the key independent variable is the *promotional reactions* predicted by Equation 2 of the first stage, $\widehat{Promo}_{it}$ (we follow the approach of Ailawadi et al. 2010). We specify the sales of model i at postrecall month t as

$$Sales_{it} = \alpha_s + \beta_{1s} \widehat{Promo}_{it} + \theta_s{}' SalesControl_{it} + Month_t + \epsilon_{sit}, \quad (3)$$

where α_s is the intercept and β_{1s} is the key effect of interest (i.e., the effect of promotional reactions on sales). $SalesControl_{it}$ is a vector of control variables, which include the postrecall MSRP, the average sales of the car model in the same month of 2006–2008, the advertising stock (over the past three months) of the focal car model, the number of dealers of the focal make, the safety rating of the focal car model, and the degree of updates of the focal car model from 2009 to 2010. These variables account for the impact of affordability, awareness, accessibility, and popularity (hence consumer preferences) of the car model on its sales. The coefficients θ_s capture the effects of these control variables on sales. We also include month fixed effects to account for potential demand seasonality.

Identification Identification of the effectiveness of promotional reactions requires the accurate estimation of $\widehat{Promo}_{it}$. This in turn relies on satisfying the previously discussed SUTVA assumption that establishes the robustness of the treatment and control groups. In addition, we need to address two econometric challenges in the second stage. First, we need to correct the standard errors of the coefficients in Equation 3. Since promotional reactions are estimated by Equation 2 (rather than observed), the standard errors of the coefficients generated from ordinary least squares are biased. Thus, we use the bootstrap method (with 500 random draws) to obtain unbiased standard errors.

Second, firms may adjust promotions of car models depending on the sales outcomes of the current period, which leads to potential endogeneity of promotional reactions. In addition, firms may set the MSRP of car models according

[9] We demonstrate the robustness of the results even when this assumption is relaxed in the Results Section.

to attributes correlated with sales, such as quality (unobservable to the researcher). To account for the potential endogeneity of promotional reactions, we apply an instrumental variable approach that is similar to that of Ailawadi et al.'s (2010). We split the postrecall seven months into the first three months and subsequent four months and then estimate Equation 3 using the sample of the subsequent four months. We use the estimated promotional reaction of the first three months as instruments for the reaction in the subsequent four months, because promotional reaction of the first three months cannot be influenced by sales of the subsequent four months. Regarding to instruments for MSRP, we use cost variables obtained from the World Bank, such as the fees levied to import (export) a 20-ft container into (from) the country of final assembly of the car model, the total importing and exporting costs averaged across countries where the car model is assembled, and the minimum wage of the country of final assembly of the car model (scaled by the minimum wage in the United States). These instruments are measured at the car model/ year level and are in that way consistent with MSRP. We expect these cost variables to be correlated with MSRP but not sales, because they are unknown to consumers.

Heterogeneity in promotional reaction on sales outcome Given our prediction that the effects of promotional reactions on postrecall sales will differ across brand tiers, we also estimate the following model:

$$Sales_{it} = \alpha_s + \beta_{1s}\widehat{Promo}_{it} + \beta_{2s}\widehat{Promo}_{it} \times ManufactPrem_i + \theta_s' SalesControl_{it} + Month_t + \epsilon_{sit}, \quad (4)$$

where variables and coefficients are defined consistently with Equation 3, $ManufactPrem_i$ is a dummy variable for the manufacturer and brand tier of the focal car model, and β_{2s} measures the effect of promotional reactions on sales of the focal manufacturer–brand tier combination above the baseline (i.e., β_{1s}).

Results

Descriptive statistics

We present the descriptive statistics of the key variables in Table 4. In addition, we present the descriptive statistics by treatment group and control group, together with time plots of promotions, sales, and advertising spending of representative brands over time, in Web Appendix B.

First-stage results

Model-free analysis For sake of illustration, we first use Honda and Acura car models as examples and compare the average promotions of treated and control car models before and after the recalls. We use observation windows of both seven months and five months. Results of the t-tests presented in Table W6 of Web Appendix B show that the average promotion of the treated car models increased significantly ($p < .05$) after the recalls, while the average promotion of the control car models did not change significantly.

We then generalize these results by comparing the average promotions of treatment and control groups before and after the Toyota recalls using all car models in the sample. Furthermore, we test the pre-post values of the two groups (i.e., a raw difference-in-differences analysis). We present these results in Table 5. While the control group had a promotion decrease of 29% (on average, from $3690.14 to $2616.90; $p < .001$), the treatment group had a marginally significant promotion decrease of 5% (on average, from $3644 to $3464.84; $p < .1$); the differences between the promotion changes are significant at the .001 level. If we repeat the same analysis separately on the samples of premium and nonpremium car models, we find that the premium treatment car models had a significantly smaller promotion drop ($1835.60; $p < .001$) than the premium control car models; however, the nonpremium car models do not exhibit the same pattern ($8.87; $p > .1$).

Model-based analyses We present the results of the first-stage estimation in Columns 1, 2, and 3 of Table 6; Column 1 displays the estimation results for Equation 1 without including make fixed effects, Column 2 displays the results of the complete version of Equation 1, and Column 3 presents the results of a parsimonious version of Equation 1 (controlling only for advertising stock, past promotions and sales in 2006–2008). The effect of interest—the interaction between treatment group and postrecall period dummy variables—is positive and marginally significant in all columns (i.e., β_{3p}= 854.26, 832.85, and 899.5, respectively; $p < .1$). These results suggest that car models in the treatment group, on average, had higher promotions after Toyota recalls than car models in the control group. In other words, most firms reacted to Toyota recalls by increasing promotions. In addition, the coefficient of the postrecall period dummy indicates a negative effect on promotions (β_{2p}= −1098.56, $p < .05$, −1026.72, $p < .1$, and −1050.18, $p < .05$, in Column 1, 2, and 3, respectively), indicating that, compared with the seven prerecall months, the average promotion level decreased in the seven postrecall months. The effect of advertising stock is positive (θ_p= 1.23, 1.39, and 1.40 in Columns 1, 2, and 3 respectively; $p < .01$), and the effect of the average promotion in the same month of 2006–2008 of the focal car model is positive (θ_p= 0.44, 0.29, and 0.29 in Columns 1, 2, and 3, respectively; $p < .01$), confirming that promotion is affected by advertising and seasonality.

Table 4 Sample correlations and descriptive statistics

	Correlation								
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Promotion	1.00								
(2) Sales	−0.244***	1.00							
(3) Price	0.435***	−0.345***	1.00						
(4) Advertising Stock	0.061**	0.050**	0.036	1.00					
(5) Number of Dealers	−0.075***	0.325***	−0.251***	0.107***	1.00				
(6) Safety	0.224***	−0.306***	0.537***	0.012	−0.249***	1.00			
(7) Updates	−0.009	0.048*	0.006	−0.037	−0.050**	0.089***	1.00		
(8) Avg. Promotion 2006–2008	0.482***	−0.236***	0.424***	−0.040	−0.016	0.114***	−0.024	1.00	
(9) Avg. Sales 2006–2008	−0.161***	0.832***	−0.318***	−0.005	0.360***	−0.309***	−0.010	−0.076***	1.00
Full Sample Summary Statistics ($N = 1666$)									
Mean	3470.197	3833.014	30,776.620	19.065	1444.794	5.550	0.069	2836.392	4734.438
Standard Deviation	2043.437	5369.845	14,448.670	121.744	1120.808	1.305	0.226	2128.839	6166.103
Min	0	0	13,994.000	0	169.000	3.667	0	0	0
Max	18,769.000	43,294.000	104,875.000	1682.500	3812.000	8.333	1.000	10,281.000	41,825.670
Skewness[#]	0.939	2.466	2.032	9.136	0.797	1.075	3.306	0.864	2.610

*p < .1, **p < .05, ***$p < .01$. [#] Skewness equals 0 for symmetric distributions

Autoregressive coefficients (with fixed effects): $Promotion_t = 0.62 \times Promotion_{t-1}$; $Sales_t = 0.25 \times Sales_{t-1}$; $Price_t = 0.86 \times Price_{t-1}$; $Advertising\ Stock_t = 0.66 \times Advertising\ Stock_{t-1}$; $Number\ of\ Dealers_t = 0.86 \times Number\ of\ Dealers_{t-1}$; $Safety_t = 0.86 \times Safety_{t-1}$; $Updates_t = 0.86 \times Updates_{t-1}$; $Avg.\ Promotion2006-2008_t = 0.49 \times Avg.\ Promotion2006-2008_{t-1}$; $Avg.\ Sales2006-2008_t = 0.35 \times Avg.\ Sales2006-2008_{t-1}$

Heterogeneity in treatment effects

We present the coefficient estimates of Equation 2 in the left-hand panel of Table 7 and the computed treatment effects of each manufacturer–brand tier combination in the right-hand panel of the same table. Among eight premium manufacturers, BMW, Ford premium, GM premium, and Honda premium had significant promotion increases ($2848.54, $2929.7, $2434.36, $2302.94 respectively) after the Toyota recalls, Daimler Premium, Jaguar Land Rover, and Volkswagen Premium had nonsignificant promotion changes, and Nissan Premium had a promotion decrease of $1942.86. In contrast, among eleven nonpremium manufacturers, only Ford and Nissan had significant promotion increases ($1215.58 and $1536.77 respectively, about half the size of those of the four premium manufacturers), Honda and Mitsubishi had

Table 5 Model-free evidence of promotional response

Group	Pre-Toyota Recall Period	Post-Toyota Recall Period	Difference	Differences-in-Differences
All Car Models				
Treatment	3644.00	3464.84	−197.16*	894.10****
	(75.06)	(76.64)	(62.40)	(164.90)
Control	3690.14	2616.90	−1073.25****	
	(196.10)	(146.20)	(217.40)	
Premium Car Models				
Treatment	6201.70	5976.40	−225.30	1835.60****
	(188.60)	(236.50)	(273.80)	(474.80)
Control	4628.20	2567.20	−2060.90****	
	(318.30)	(230.10)	(392.80)	
Nonpremium Car Models				
Treatment	3158.40	2988.00	−170.40*	−8.87
	(63.47)	(61.12)	(52.23)	(141.00)
Control	2824.30	2662.70	−161.50	
	(198.50)	(185.40)	(127.50)	

* p < .1, ** p < .05, *** p < .01, **** p < .001

Table 6 First-stage estimation results (promotion as dependent variable)

DV: Promotion	(1) Equation 1,without Make Fixed Effects	(2) Equation 1, Full Model	(3) Equation 1, Parsimonious
Treatment	177.00	526.07	440.25
	(418.23)	(390.35)	(390.02)
Postrecall	−1098.56**	−1026.72*	−1050.18**
	(526.28)	(538.61)	(510.39)
Treatment × Postrecall	854.26*	831.85*	899.50*
	(511.13)	(500.53)	(521.57)
Advertising Stock	1.23***	1.39***	1.40***
	(0.274)	(0.410)	(0.40)
Number of Dealers	−0.068	−0.508	
	(0.101)	(0.531)	
Safety	253.50**	110.31	
	(96.50)	(99.78)	
Updates	336.42	−415.65	
	(651.18)	(494.21)	
Avg. Promotion 2006–2008	0.44***	0.29***	0.29***
	(0.05)	(0.06)	(0.06)
Avg. Sales 2006–2008	−0.03***	0.01	0.01
	(0.02)	(0.01)	(0.01)
Constant	1084.27	1784.95***	2223.13***
	(750.36)	(654.88)	(427.70)
Make fixed effects	No	Yes	Yes
Observations	1666	1666	1666
Adjusted R^2	0.30	0.45	0.45

*p < .1, **p < .05, ***p < .01

marginally significant promotion increases ($1070.68 and $976.8 respectively), and Chrysler, GM, Hyundai, Mazda, Subaru, Suzuki, and Volkswagen had nonsignificant promotion changes. We summarize the distribution of the percentage promotion changes for premium and nonpremium manufacturers in Panel A of Table 8. Overall, while we cannot interpret the lack of statistical significance as absence of reactions, the results do support our predictions that premium car models were more likely than nonpremium car models to increase promotions after the Toyota recalls, and if premium brands increased promotions, the average effect size was larger than that of the nonpremium car models.

Second-stage results

Estimates As discussed previously, we use an instrumental variable approach to address the potential endogeneity of promotional reaction and MSRP. The F-values of the first-stage regressions are 3657.4 and 28, respectively, for promotional reaction and MSRP (see Table W7 in Web Appendix C). The F-values of the regressions with only the instrumental variables are 4304.89 and 20.63, respectively, for promotional reaction and MSRP. These results confirm the explanatory power of the instrumental variables. We present the second-stage regression results in Column 1 of Table 9. Among the control variables, the effects of advertising stock (.66, $p < .01$), number of dealers (.15, $p < .05$), updates (1824.8, $p < .01$), and average sales in the same month of 2006–2008 (.66, $p < .01$) are positive, which indicates that in the seven months after Toyota's recalls (1) past advertising, distribution network, and innovation significantly affect sales, and (2) the sales of a car model exhibit strong seasonality and inertia. The average effect of promotional reaction on sales is nonsignificant.

Heterogeneity in the effect of promotional reaction on sales

We present the estimation results of Equation 4 in Column 2 of Table 9. The baseline (i.e., nonpremium GM) effect of promotional reactions on sales is not significantly different from zero. However, all premium manufacturers (except Jaguar/Land Rover) have significantly positive effects above that of the baseline. Among the premium manufacturers, the effect size of Daimler (Mercedes-Benz) and Volkswagen (Audi) is greater than 1. Nonpremium manufacturers have very different sales effects of promotional reactions: Ford and Nissan are the only manufacturers that had a positive effect, while Mazda, Suzuki, and Volkswagen had negative effects of

Table 7 First-stage estimation (promotion as dependent variable): manufacturer–brand tier treatment effects

Coefficient Estimates		Treatment Effects by Manufacturer–Brand Tier	
Treatment × Postrecall	2848.54***	BMW Premium	2848.54***
	(1039.36)		(1039.36)
Treatment × Postrecall × Chrysler	−2556.17**	Chrysler	292.37
	(1036.24)		(578.26)
Treatment × Postrecall × Daimler Premium	−2017.10*	Daimler Premium	831.44
	(111.53)		(768.26)
Treatment × Postrecall × Ford	−1632.96	Ford	1215.58**
	(1039.57)		(574.34)
Treatment × Postrecall × Ford Premium	81.16	Ford Premium	2929.70**
	(1496.84)		(1327.30)
Treatment × Postrecall × GM	−2192.03**	GM	656.52
	(1061.71)		(576.90)
Treatment ×Postrecall × GM Premium	−414.19	GM Premium	2434.36***
	(1153.82)		(795.20)
Treatment × Postrecall × Honda	−1777.86*	Honda	1070.68*
	(1043.51)		(624.65)
Treatment × Postrecall × Honda Premium	−545.60	Honda Premium	2302.94***
	(1002.97)		(557.66)
Treatment × Postrecall × Hyundai	−2573.98**	Hyundai	274.57
	(1016.63)		(537.40)
Treatment × Postrecall × Jaguar Land Rover	−2175.66	Jaguar Land Rover	672.88
	(1427.26)		(1159.52)
Treatment × Postrecall × Mazda	−2610.63**	Mazda	237.91
	(1027.75)		(584.10)
Treatment × Postrecall × Mitsubishi	−1871.74*	Mitsubishi	976.80*
	(1030.63)		(529.81)
Treatment × Postrecall × Nissan	−1311.78	Nissan	1536.77**
	(1064.23)		(589.68)
Treatment × Postrecall × Nissan Premium	−4791.40***	Nissan Premium	−1942.86***
	(1026.71)		(522.89)
Treatment × Postrecall × Subaru	−2356.11*	Subaru	492.44
	(1198.36)		(809.34)
Treatment × Postrecall × Suzuki	−2747.71**	Suzuki	100.84
	(1323.82)		(1045.98)
Treatment × Postrecall × Volkswagen	−3247.13***	Volkswagen	−398.59
	(1073.91)		(735.92)
Treatment × Postrecall × Volkswagen Premium	−2071.11**	Volkswagen Premium	777.43
	(1040.04)		(548.50)
Treatment	243.13		
	(360.57)		
Postrecall	−1011.54*		
	(526.61)		
Observations	1666		
R^2	0.47		

*p < .1, **p < .05, ***p < .01

promotional reactions; other manufacturers have nonsignificant effects of promotional reactions on sales. We present the distribution of promotion effects on sales of premium and nonpremium manufacturers in Panel B of Table 8. Overall, the promotional reactions of premium car models seemed effective in increasing sales after Toyota's recalls; in contrast,

Table 8 Distribution comparison between brand tiers

A: Distribution of Treatment Effects by Manufacturer–Brand Tier

	Positive	Marginally Positive	Nonsignificant	Negative
Premium	50%	0%	37.50%	12.50%
Nonpremium	18.18%	18.18%	63.64%	0

B: Distribution of Promotional Reaction Effects on Sales by Manufacturer–Brand Tier

	Positive (≥1)	Positive (<1)	Null Effects	Negative (> − 1)	Negative (<−1)
Premium	28.57%	57.14%	14.29%	0	0
Nonpremium	0	18.18%	54.54%	9.09%	18.18%

the promotional reactions of most nonpremium car models were ineffective or even led to decreased sales.[10] These results provide empirical support to our predictions.

Robustness tests

We conducted a series of robustness tests for both estimation stages. We briefly describe four of these tests in this section, and present their technical details in Web Appendix D together with additional robustness tests. We provide a summary index of robustness tests in Table 10.

First stage estimation robustness tests

We conducted multiple tests to demonstrate the robustness of the first stage estimation results to alternative model specifications, measurements, observation windows, and samples, as well as the relaxation of the assumption of no interference between treated and control units. The details appear in Web Appendix D. In this section we focus on providing a general discussion of the robustness of the first-stage estimation results to alternative explanations.

Promotional reactions to Toyota recalls or Toyota postrecall promotions After the recall, Toyota increased promotions to counter weakened quality perceptions and prevent sales losses (Halvorson 2010; Rooney 2010). Therefore, it is important to clarify whether the promotion increase we observe among Toyota's competitors is a reaction to Toyota recalls or to the postrecall promotions of Toyota/Lexus car models. If firms reacted to Toyota's promotions, we should observe positive associations between promotions of Toyota/Lexus car models and the promotions of car models competing in the same categories. To empirically test this hypothesis, we include the average promotion of Toyota/Lexus car models competing in the category of the focal model as a control variable (refer to Web Appendix D for details). Results in Column 3 of Table W8 show that the effect of interest remains positive and marginally significant, whereas $ToyotaPromo_{it}$ does not have a significant effect, indicating that firms reacted to *Toyota recalls* rather than to the postrecall increase in promotions of Toyota/Lexus car models.

Cash for clunkers program The Cash for Clunkers program implemented in 2009 may have increased the market preference for, and promotions of fuel-efficient car models. Matching treated car models to control car models by MPG prevents this mechanism from possibly affecting the findings. In addition, we compare the MPG of car models in the treatment and control groups in 2009 and 2010 and find no significant difference. Therefore, the differences in promotional reactions between the two groups are unlikely driven by the Cash for Clunkers program in this observation window.

Differences in general promotion trends before and after Toyota recalls If the treatment effect was caused by differences in general promotion trends across car categories before and after Toyota recalls, we would observe significant differences in promotion change between different categories within the treatment group. We use a sample with only car models in the treatment group, define sedans as the placebo treatment group and light trucks as the placebo control group, and estimate Equation 1 again. The results reported in Column 4 of Table W8 and Column 7 of Table W9 show nonsignificant placebo treatment effects, confirming that the treatment effect is not caused by different promotion trends across car categories.

Differences in promotion budgets The promotion level of a car model may be correlated with the car model's MSRP because markups are higher for premium vehicles and thus premium manufacturers may have larger promotional budgets. The difference in the average retail price between the two groups may thus affect the average pre- and postdifferences in promotions across brand tiers. As robustness tests, we estimate Equation 1 using two alternative measures of promotion: the promotion standardized by MSRP and the Box-Cox transformed promotion. The results, presented in Columns 5 and 6 of Table W8 are consistent with those in Table 6.

[10] Interviews with sales managers at dealerships of nine different brands suggest that a majority of the managers believe that if a major recall happens to their brands, competing car models would increase promotions; but only some managers suggested promotional reactions help sales.

Table 9 Second-stage estimation results (sales as dependent variable)

DV: Sales	(1)		(2)	
Variable	Beta Coefficient	Standard Error	Beta Coefficient	Standard Error
Promotional Reaction (base GM)	−0.31	0.23	−1.27	0.80
Promotional Reaction × BMW Premium			0.83***	0.14
Promotional Reaction × Chrysler			−0.08	0.19
Promotional Reaction × Daimler Premium			2.00*	1.14
Promotional Reaction × Ford			0.48***	0.17
Promotional Reaction × Ford Premium			0.91***	0.18
Promotional Reaction × GM Premium			0.92***	0.15
Promotional Reaction × Honda			−0.76	0.82
Promotional Reaction × Honda Premium			0.93***	0.26
Promotional Reaction × Hyundai			0.11	0.36
Promotional Reaction × Jaguar Land Rover			1.14	0.86
Promotional Reaction × Mazda			−1.39***	0.35
Promotional Reaction × Mitsubishi			−0.25	0.28
Promotional Reaction × Nissan			0.40***	0.13
Promotional Reaction × Subaru			0.93	1.31
Promotional Reaction × Suzuki			−1.48**	0.62
Promotional Reaction × Volkswagen			−0.61**	0.26
Promotional Reaction × Volkswagen Premium			1.68***	0.57
Price	−0.08	0.05	−0.14	0.09
Advertising Stock	0.66***	0.01	3.31***	0.56
Number of Dealers	0.15**	0.07	0.37	0.33
Safety	29.54	143.45	0.67	93.53
Updates	1824.80***	96.80	1360.42***	346.94
Avg. Sales 2006–2008	0.66***	0.01	0.65***	0.04
Constant	3001.01***	148.19	8027.04***	1406.34
Time fixed effects	Yes		Yes	
Observations	316		316	
R^2	0.77		0.81	

*p < .1, **p < .05, ***p < .01

The number of observations used in the second-stage estimation is lower than that used in the first-stage estimation because only the records of treated car models in the last four months of the postrecall period are included in the sample. Please refer to Estimation Methodology Section for more details

Second stage estimation robustness tests

We conducted robustness tests for the second stage analysis using alternative model specifications, alternative measures of promotional reactions and advertising stock, and an alternative dependent variable (i.e., market share). The results are qualitatively consistent with the main results. We discuss the details in Web Appendix D.

Discussion and conclusion

Even though existing studies have investigated various research questions related to product recalls and brand crisis, it is unclear how firms should respond to a competitor's recall and what outcomes firms should expect from these responses. In this research, we explore firms' promotional reactions to major recalls of a competitor, the effectiveness of these promotional reactions on postrecall sales, and the heterogeneity in both promotional reactions and their effectiveness across brand tiers. We first establish the effects of Toyota's recalls on competing firms' promotional reactions, using a quasi-experimental method. We find that firms, particularly those offering premium brands, increased promotions in the same categories as the recalled products. Regarding promotional reaction effectiveness, we find that the effects of promotional reactions on sales were heterogeneous and differ across premium and nonpremium brands; they were predominantly positive for premium brands and

Table 10 Summary index of robustness tests

Estimation	Robustness Test	Results
First Stage Estimation	Alternative model specification with car model fixed effects and month fixed effects	Table W8, Columns 1 and 2
	Alternative explanation – firms reacted to postrecall promotions of Toyota/Lexus car models	Table W8, Column 3
	Alternative explanation – Cash for Clunkers Program	Comparable average MPG between the treatment and control groups: 20.48 vs. 20.04, $p = .61$
	Alternative explanation – differences in general promotion trends across car categories before and after Toyota recalls	Table W8, Column 4; Table W9, Column 7
	Assumption of no interference between treated and control units	See details in Web Appendix D
	Alternative measure of promotion	Table W8, Columns 5 and 6
	Alternative measure of advertising stock	Table W9, Column 1
	Alternative observation windows	Table W9, Columns 2–4
	Alternative matching procedures and samples	Table W9, Columns 5 and 6
Second Stage Estimation	Alternative measure of promotion	Table W10, Column 1
	Alternative model specification with a random intercept	Table W10, Column 2
	Alternative measure of advertising stock	Table W10, Column 3 and Table W11
	Alternative dependent variable (market share)	Table W12

mostly nonsignificant or negative for nonpremium brands. These findings translate into two key takeaways for the literature on product recalls and brand crisis.

Takeaway 1: Our results show that although both premium and nonpremium firms reacted to Toyota's recalls by lowering their prices, the price discounts were larger and more common for premium brands, perhaps because the safety concerns raised by the recalls made consumers loyal to nonpremium brands less price sensitive and more likely to switch to premium brands if these became more affordable. This finding identifies a heretofore-unstudied boundary condition for common promotional strategies adopted by different brand tiers. Prior research argues that under normal circumstances, premium brands rarely cut prices to boost sales (e.g., Heil and Helsen 2001; Kapferer and Bastien 2012), because promotions harm brand equity and high brand equity is what allows premium brands to justify premium prices (Blattberg et al. 1995; Sriram and Kalwani 2007). At the same time, the recall might have protected premium brands from the negative effect of promotions on brand equity (Heil and Helsen 2001; Kapferer and Bastien 2012) since premium brands already enjoyed greater perceived safety and vertical quality. Accordingly, premium brands may have viewed Toyota's recalls as opportunities to draw demand and thus temporarily increase promotions.

Takeaway 2: Our findings reveal a boundary condition for the impact of promotions on sales. Extant research typically demonstrates a positive immediate impact of promotions on sales (e.g., Blattberg and Neslin 1990; Guadagni and Little 1983). We surmise that recalls may make safety more salient to consumers and may enhance their preferences for vertical quality, and as a result, promotions of products with weak perceived vertical quality may backfire. However, premium brands could enjoy relatively larger postrecall promotion effectiveness because of higher perceived vertical quality (Blattberg et al. 1995).

Managerial implications

To provide manufacturer-specific insights, in Table 11 we categorize manufacturer–brand tier combinations in the treatment group along two dimensions: the average predicted promotion change (in dollars) from before to after the Toyota recalls (estimated from Equation 2) and whether the effect of promotional reactions on sales is above the baseline (nonpremium GM). We find particular differences in promotional effectiveness between the premium and nonpremium brands of the same manufacturer. For example, the figures in Table 11 indicate that increased promotion would lead to decreased sales for Volkswagen (i.e., coefficient −.61) but may increase sales for Audi, the premium brand of Volkswagen (i.e., coefficient 1.68). Furthermore, we find that many car manufacturers' promotion changes are aligned with their promotion effectiveness. For example, Mazda and Suzuki experienced large and negative effects of promotion on sales (−1.39 and −1.48 relative to the baseline), but they also decreased promotions after the Toyota recalls (by $767.1 and $1089.43 per vehicle, respectively), thus not wasting incentives. In contrast, Audi (Volkswagen premium) and

Table 11 Promotion change and promotion effectiveness by manufacturer–brand tier

Manufacturer–Brand Tier	Promotion Change	Promotion Effects on Sales
Promotion Increase, Promotion Effects on Sales Below or Equal to Baseline		
Honda	33.82	−0.76
Mitsubishi	95.57	−0.25
Promotion Decrease or No Significant Change, Promotion Effects on Sales Below or Equal to Baseline		
Chrysler	−444.66	−0.08
GM	−147.25	0
Hyundai	−793.99	0.11
Jaguar Land rover	-935.86	1.53
Subaru	−488.43	0.93
Mazda	−767.10	−1.39
Suzuki	−1089.43	−1.48
Volkswagen	−1537.37	−0.61
Promotion Increase, Promotion Effects on Sales Above Baseline		
BMW Premium	1177.63	0.83
Ford	265.18	0.48
Ford Premium	1550.30	0.91
GM Premium	1384.62	0.92
Honda Premium	1336.65	0.93
Nissan	500.75	0.4
Promotion Decrease or No Significant Change, Promotion Effects on Sales Above Baseline		
Daimler Premium	−526.42	2.00
Volkswagen Premium	−351.36	1.68

Mercedes-Benz (Daimler premium) had above-average promotion effectiveness (1.68 and 2 relative to the baseline) but decreased promotions (by $351.36 and $526.42 per vehicle, respectively) after the Toyota recalls, probably missing the opportunity to increase sales and expand their markets. Finally, it is possible that Honda and Mitsubishi could have saved some incentive expenditures because of their negative or nonsignificant promotion effectiveness (−.76 and −.25 relative to the baseline). Based on our results, we provide three additional takeaways for firms and policymakers.

Takeaway 3: Promotional responses by firms after a competitor's recall may not result in universally positive outcomes. Firms should better understand how product recalls can affect consumers' product preferences, which in turn influence their perceptions of promotions. Although product recalls may provide opportunities for competing firms to expand their markets in the short run, we suggest that firms should be cautious to increase promotions promptly after major recalls (i.e., recalls related to serious quality or safety issues). They should first carefully evaluate their perceived vertical quality and then decide on their promotional responses.

Takeaway 4: Premium brands should be aware that product recalls may enhance consumers' preference towards products with high vertical quality, and consequently the effectiveness of their promotional responses on postrecall sales may be higher than that of the responses of nonpremium brands. Therefore, they may miss good opportunities to increase sales and market shares if they do not promote after a competitor's major recall. Take Audi and Mercedes-Benz for example; if they had not decreased their promotions after Toyota's recalls, their sales could have increased by about 590 and 1053 units respectively, and if they had increased their promotions by $300 per vehicle, their sales could have increased by about 1094 and 1653 units. In contrast, many nonpremium brands should be cautious to increase promotion after a competitor's recall, because they may avoid losses by not promoting. For example, if Honda and Mitsubishi had not increased promotions, their sales levels could have been the same, but they would have saved $33,820 and $95,570 on promotional expenses per each 1000 unit sales.

Takeaway 5: It is well known that without proper regulations, heavy promotions may lead to price wars and other unsustainable competitive responses (Heil and Helsen 2001). Thus, public policy makers could consider regulating firms' promotions after a major recall, so that both firms and consumers are properly protected from negative long term consequences.

Limitations and future research

We discuss several limitations of this paper. First, our monthly data structure prevents us from exploring firms' reactions to the reactions of other firms to the recall nor their effects on sales at a more granular level (e.g., daily promotion and sales). Second, our promotion variable measures effective promotions—that is, manufacturer promotions applied to actual transactions.

However, sometimes dealers may not pass promotions through to consumers. Our data do not separate manufacturer and dealer behavior, and thus we focus on effective promotions. Busse et al. (2006) have explored the role of dealers in promotion pass-through. Third, our measure includes, but does not separate, nonmonetary promotions such as financing rates and unemployment warranties. While we cannot provide separate insights for different types of promotions, we do provide evidence of significant aggregate promotional reactions to the Toyota recalls. It would be fruitful for future research to explore reactions in terms of different types of promotions. Fourth, our methodology and data set prevent us from accurately measuring the mid- and long-term effects of the recall on promotions, which we hope future research can investigate. Fifth, the observational nature of our approach allows us to draw insights regarding firms' behaviors but not regarding firms' intentions. Sixth, despite matching car models by manufacturer-brand tier, attributes, and MSRP, the strong within-brand product differentiation in the automobile industry makes it impossible for us to find a control group that is very similar to the treatment group. We encourage future research to replicate this research in other context where products are less differentiated. Seventh, the sample size prevents us from interpreting non-significant effects as absence of reactions. We can only claim that certain firms were more likely than others to react. Finally, we investigated an industry in which list prices cannot be used as short-term competitive reactions (list prices normally change only once every year) and a sample in which advertising spending is rarely observed. We encourage future research on this topic to consider alternative product categories for which these limitations do not apply.

Acknowledgements The authors thank the Darla Moore School of Business for financial support. They also thank Gary Lilien, Marnik Dekimpe, Venkatesh Shankar, Linli Xu, Yi Zhu, Seshadri Tirunillai, Cem Ozturk, Fue Zeng, and participants at the Marketing Science Conference 2016 for their valuable comments.

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