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The Role of Social Media and Brand Equity During a Product Recall Crisis: A Shareholder Value Perspective

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Abstract

Utilizing an event study methodology of 185 product recall announcements, this study examines to what extent social media hurts a company's shareholder value in the event of a product recall. In addition, we explore whether a company's brand equity and engagement in online chatter potentially mitigate the negative effects of social media surrounding the recall. We operationalize four metrics of online word-of-mouth (WOM) that may moderate negative product recall effects: volume, valence, growth rate, and breadth. The findings suggest that product recalls result in significantly negative abnormal returns for firms. Furthermore, the volume, valence and growth rate of online WOM exacerbate this negative effect of a product recall on firm value. Most importantly, we find negative effects of the volume and the valence of online WOM on firm value are lower for brands with strong brand equity. Surprisingly, we find no effect of company involvement in mitigating the potential negative effects of social media during a product recall. Our findings highlight the threats of product recalls and demonstrate that building brand equity may help protect a company in the social media environment.

Keywords: Online Word-of-Mouth, Brand Equity, Product Recall, Event Study

1. Introduction

> *The vehicles we make today are the best in memory and I'm confident that they will do fine, on their own merits. And our company's reputation won't be determined by the recall itself, but by how we address the problem going forward. What is important is taking great care of our customers and showing that it really is a new day at GM.*
>
> – Mary Barra CEO General Motors

In her open letter to General Motors' employees, commenting on the massive recall of cars related to faulty ignition switches, Mary Barra stresses the importance of the company's brand equity in addressing the problem. One way GM has tackled the recall is via a social media strategy focused on Facebook and Twitter, communicating directly with individual consumer posts (Goel, 2014). In a social media environment, consumers not only post their opinions about the brand but they also observe how the brand reacts and treats others. How this environment affects the consequence of a product recall event and how to overcome a product recall crisis in the presence of online social media, has become an important strategic question for the firm.

Based on USASearch's Product Recall Data, from January 2010 to December 2013 there were 5,861 product recall announcements across various industries. On average, four product recall announcements occur every day. Therefore, "it is probably only a matter of time for any product manufacturer to have one or more products recalled" (Berman, 1999, p. 69). Product recall events impose legal costs, affect sales, raise manufacturing costs, dilute brand equity, and hurt financial value, posing a significant threat for brands and companies (Chen, Ganesan, & Liu, 2009; Thirumalai & Sinha, 2011). There are substantial direct costs (e.g., cost of implementing the recall, lost inventory, and reversed sales) and indirect costs (e.g., product liability claims and negative brand image) incurred when a product is recalled due to the presence of unsafe, hazardous, or defective conditions (Pruitt & Peterson, 1986). It is imperative for companies to understand the potential damage product recalls may inflict while finding ways to mitigate their harm.

Empirical work examining product-harm crises is scant and scattered across a number of functional areas with most attention focused on positive and negative consequences of the recall. On the positive side, the resulting outcome consists of reducing the number of injuries and recalls in the future (Kalaignanam, Kushwaha, & Eilert, 2013). On the negative side, product recall announcements have been documented to reduce demand (Marsh, Schroeder, & Mintert, 2004) and decrease future purchase intentions (Siomkos & Kurzbard, 1994). Recalls have also resulted in significant shareholder losses for publicly traded companies in the automobile and the food and drug industries (Davidson & Worrell, 1992; Jarrell & Peltzman, 1985; Thomsen & McKenzie, 2001). More seriously, the loss of shareholder value is often substantially greater than the direct cost of the recall itself, including those associated with destroying or repairing defective products (Govindaraj, Jaggi, & Lin, 2004). This market overreaction is generally based on pessimistic expectations of all potential losses associated with a recall including opportunity losses related to future sales because of brand deterioration and private litigation (Rubel, Naik, & Srinivasan, 2011). Investors are particularly sensitive to market information and react abruptly to exposures that put expected future cash flow at risk (Govindaraj, et al., 2004).

Still, extant work in the area of product recalls has yet to consider how the evolving social media environment affects marketplace responses. More specifically, the impact of online word-of-mouth (WOM) on the stock market in the event of a product recall crisis has yet to be explored. Social media has created new rules and challenges for marketing strategy (Deighton, 2010; Fournier & Avery, 2011). We are all too familiar with the popular social media platforms (e.g., WordPress, Twitter, YouTube, and Facebook) that have proliferated in the media landscape to yield significant influence on organizations under a product recall crisis. For example, when Toyota announced a product recall on January 26, 2010, in light of an accelerator pedal problem, sixty percent of the online chatter about Toyota during the subsequent week was associated with key words including “recall,” “pedal,” and “fix” (Brownsell, 2010). At the time, Toyota suffered a seventeen percent weekly plunge in share price (down from $86.78 to $71.78) as markets reacted to its enhanced risk exposure. Despite anecdotal evidence, an empirical gap remains with regard to the effects of social media on firm value within the context of a product recall crisis. The overarching goal of this study is to examine social media effects and their interaction with the role of brand on shareholder value during a product recall crisis.

This study delineates four metrics of online WOM that may exacerbate negative product recall effects: volume, valence, growth rate, and breadth. The majority of research in the online WOM area has explored two metrics, its volume and valence (Dellarocas & Narayan, 2006). New communication channels such as blogs and tweets represent potent threats to firms because small-scale WOM can inflict a large-scale impact on a company’s brand equity and shareholder value (Gaines-Ross, 2010). Researchers have found that volume of online WOM plays an important role in influencing product sales (Chevalier & Mayzlin, 2006; Duan, Gu, & Whinston, 2008).

The valence of online WOM has proven to have significant impact on companies (Chen, Liu, & Zhang, 2012; Chevalier & Mayzlin, 2006; Godes & Mayzlin, 2004; Tirunillai & Tellis, 2012). Empirical evidence has also shown that the market reactions to postings of rumors on the Internet can significantly influence stock returns and trading volume (Clarkson, Joyce, & Tutticci, 2006). Although speed of delivery and multiple information platforms are important features in the Web 2.0 environment (Kaplan & Haenlein, 2010) the growth rate and breadth of online WOM are largely ignored in the literature. Rust et al. (2004) stated that, "there is much yet to be learned about how the Internet environment affects the customer. In general, increased communications and computations capabilities change the nature of the relationship between the marketer and the consumer in ways that are not yet fully understood" (p. 84, emphasis added). A second goal of this study is to provide diagnostic insight into how different social media metrics may moderate the impact of a product recall announcement on firm value.

Additionally, we examine the level of company involvement in social media during a product recall crisis and how such actions may attenuate the negative effect on stock performance. Though prior research in the domain of product recalls has examined company response strategies (Chen et al., 2009), the aforementioned characteristics of the Web 2.0 environment may fundamentally alter a company's optimum product recall strategy. Although companies cannot control the spread of WOM on the Web, they can use social media to get involved in conversations and influence and shape discussions in the desirable direction of a company's mission.

Lastly, the influence of social media on stock performance may not be homogeneous across brands (Iyengar, Han, & Gupta, 2009). Conventionally, branding is viewed as a strategic tool for the planning and execution of a firm's risk management projects (Rego, Billett, & Morgan, 2009). However, a deep understanding of the risk mitigation properties of brands is largely underdeveloped, especially in the Web 2.0 environment. Two powerful forces confronting brands in this new environment are transparency and criticism (Fournier & Avery, 2011). Crisis events are especially evocative for these dimensions, and the social media environment exacerbates crisis effects. Companies with strong brand equity may command loyalty and price premiums, but they also demand responsiveness and transparency to a greater degree. This issue raises the question as to whether a company's brand equity works for or against it in a rich social media environment. This study provides a novel empirical examination of the interaction effect between social media metrics and the role of brand equity in the digital arena during a product recall crisis.

Our results provide guidance to firms reacting to recall events that could potentially damage firm value. The study has practical implications for crisis management as well as theoretical insights for scholars in the field of product recall management and marketing communications. According to the findings, managers should monitor online WOM as a part of their product recall crisis management, particularly negative online WOM and increased growth of online WOM. Figuring out ways to reduce the growth rate of WOM and attenuating the negative valence of such postings may be one strategy a firm can undertake. Our findings also reveal a similar and significant, though less robust, effect of the volume of online WOM on firm value during a product recall event. Surprisingly, we find that company involvement in social media does not moderate the impact of social media metrics on firm value. Rather our study points to the importance of building brand equity to mitigate the impact of recalls on firm value.

We organize the remainder of the article as follows: We first present our conceptual framework and hypotheses. Next, we discuss our modeling approach and describe our data and the operationalization of the variables. We then present our findings and summarize their theoretical and managerial implications, as well as the limitations of our research.

2. Conceptual framework

In general, a product recall crisis is perceived as an unfavorable and unexpected event (e.g., Pruitt & Peterson, 1986). The stock market responds to a recall efficiently once all market participants receive the information following the first public release date of the recall (Chu, Lin, & Prather, 2005; Rupp, 2004). Stock returns reflect the expected future cash flow of companies and changes in economy-wide and firm-specific information (Charoenrook & Lewis, 2009). The announcement of a product recall suggests changes in future cash flow, resulting in abnormal stock returns (Govindaraj, et al., 2004).

Social media technologies such as the Internet, social networking, and mobile broadband have fundamentally changed the way people connect with each other and with brands. Online WOM is defined as “any positive or negative statement made by potential, actual, or former customers about a product or a company, which is made available to a multitude of people and institutions via the Internet” (Hennig-Thurau, Gwinner, Walsh, & Gremler, 2004, p. 39). Online WOM can influence customer perceptions of the overall value of a firm’s offering (Gruen, Osmonbekov, & Czaplewski, 2006). In addition, WOM referrals through Internet social networking sites have substantially longer carryover effects than traditional marketing (Trusov, Bucklin, & Pauwels, 2009). Bickart and Schindler (2001) show that online WOM generates greater credibility and relevant information and evokes greater interest and empathy in product topics than the sources of information marketers create on corporate websites. Thus, the amount of control companies have over the content and distribution of the message is limited due to the consumers' ability to disseminate information with several others (Mangold & Faulds, 2009).

Building on these perspectives, we integrate emerging insights from the literature on product recalls, shareholder value, online WOM, and brand equity into a process framework that helps enumerate and explain proposed hypotheses. Figure 1 provides the conceptual framework for investigating the effects of product recalls, online WOM, and brand equity on shareholder value and provides a road map for the organization of the hypotheses in the present study. We first consider the moderating effect of social media metrics in terms of online WOM and a company's involvement in social media during the product recall crises. Next, we discuss the interaction effect between social media and brand equity on stock performance.

--- Insert Figure 1 about here ---

2.1. Moderating Effects of Social Media Metrics

With the proliferation of social media that offers instant, low cost, and wide access to communications, the negative impact of a product recall crisis on stock performance may be more severe. We consider four types of online WOM metrics: (1) volume, (2) valence, (3) growth rate, and (4) breadth. Then, we discuss a company's social media strategy in response to a crisis that may provide an opportunity to reverse the unfavorable impact of crisis events.

A product recall crisis is a negative event, regularly accompanied by negative publicity and press. The raw amount of WOM that is generated drives consumer behavior and market outcomes significantly. From information processing theory, we know that exposure frequency substantially influences brand attitude and choice (Baker, 1999). Moreover, the accessibility of information is more dominant and pivotal in decision making than the quality of the information or its source (O'Reilly, 1982). Duan, Gu, and Whinston (2008) find that while ratings have no impact, the number of online posts significantly increases movie sales. These findings suggest that consumers are more influenced by the awareness effect generated by online WOM than by the persuasive effect of online WOM. Nevertheless, given the implicit assumption that product recall crises are unfavorable information, consumers who are exposed to a large amount of product recall information may more negatively adjust their thoughts and evaluation of the firm (Dean, 2004). When there is a large amount of WOM about a product recall, the recall news receives greater attention and perhaps criticism from the community that, in turn, may magnify the negative impact of product recall crises. As a result, higher volume of online WOM about a product recall should affect firm value negatively by decreasing the level of cash flows. In addition, the volume of WOM increases investor concerns on the potential negative impact of a product recall crisis. Therefore, we propose that:

H_1. The negative impact of a product recall crisis on abnormal returns is larger when the amount of online WOM increases.

According to prospect theory, the effects of online WOM may not be homogeneous because "losses loom larger than gains" (Kahneman & Tversky, 1979, p. 263). Basuroy, Chatterjee, and Ravid (2003) find that negative reviews of a movie hurt box-office performance more than positive reviews help its performance. Similarly, Chevalier and Mayzlin (2006) empirically demonstrate that incremental negative book reviews (i.e., one-star reviews) were more powerful in decreasing book sales than incremental positive book reviews (i.e., five-star reviews) were in increasing sales. The effect of negative online WOM is also greater than positive online WOM because negative information magnifies consumers' uncertainties and fears about product quality (Smith & Vogt, 1995). Compared to the volume of online WOM that increases consumer awareness and hence manifests effects early in the process (i.e., upper funnel effect), the role of the valence of online WOM is more about influencing consumer attitude (i.e., lower funnel effect) at subsequent decision-making stages (Liu, 2006).

Not only can online WOM affect a company's revenue and sales, but it can also affect a firm's stock performance. In the airline industry, Luo (2007) finds that consumer complaints induced consumers to switch companies, thereby reducing firm revenues and consequently harming stock returns. In addition, Luo (2009) finds that more negative WOM, as manifested in the number of U.S. Department of Transportation (DOT) complaints, resulted in lower stock returns. Negative online WOM has an immediate, strong impact on stock returns and lingers longer than positive online WOM (Tirunillai & Tellis, 2012). Evidence shows that negative information is more salient and receives greater scrutiny than positive information. By examining WOM on customer acquisition for a video-on-demand service, Nam, Manchanda, and Chintagunta (2010) find that the effect of negative WOM (i.e., poor signal quality) is more than twice as large as the effect of positive WOM (i.e., great signal quality). Due to the negativity bias effect (Rozin & Royzman, 2001), investors may discount or ignore positive online WOM while paying more attention to negative valence WOM. Overall, we expect that:

H_2. The negative impact of a product recall crisis on abnormal returns is larger when the proportion of negative online WOM increases.

When companies disappoint their customers, the speed of social media causes those companies to fall painfully and instantly (Barwise & Meehan, 2010). Recently, marketers have become more aware of the fact that negative product-related information and WOM can spread across the Internet very quickly (Ward & Ostrom, 2006). For example, when Dave Carroll put his “United Breaks Guitars” video on YouTube, it received 1.5 million views within four days of posting (CBC News, 2009). United Airlines’ stock price plunged by ten percent, costing shareholders an estimated $180 million (Ayres, 2009). The growth rate of information indicates the level of public interest and concern for an event and captures the willingness and interest of people to share information. With the proliferation of social media, allowing for low-cost and instant access to communications, the negative impact of a product recall crisis on stock performance may be more severe. Investors can observe the rate of diffusion of negative information about a product recall. Rapid diffusion of negative WOM observed by the investing public via social media results in declining stock prices and uncertainty about the future earnings of the company.

Prior to social media, companies had considerable time to choose an appropriate strategy for responding to crises. In this environment selective information could be released to the public via mass media and through corporate public relations channels. However, in the current climate technological advances and the speed of social media can quickly render the company's response strategy out of date (Barwise & Meehan, 2010). When a product recall crisis occurs, consumers and other stakeholders demand explanations concerning what happened and expect a quick, appropriate response from the affected company (Pearson & Clair, 1998). The faster information spreads, the shorter a given company's reaction time, which makes it more difficult to assure the public that the crisis is being addressed and is under control. The speed by which WOM spreads raises consumer concerns, reducing firm value. Thus, we hypothesize the following:

H_3. The negative impact of a product recall crisis on abnormal returns is larger when the growth rate of online WOM increases.

Online WOM can appear on various social media platforms such as multi-media upload-sites (e.g., YouTube, Flickr), weblogs (e.g., Google Blogger), micro-blogging (e.g., Twitter, Plurk), and social network sites (e.g., Facebook). Each social media platform has distinctive characteristics, functions and users (Rooderkerk & Pauwels, 2011). The platform online WOM is posted to is used by consumers as one of the cues to judge the credibility of online WOM (Senecal & Nantel, 2004). Extant studies have focused primarily on the volume and the valence of online WOM while few researchers have examined the breadth of online WOM. Godes and Mayzlin (2004) offer an exception by examining two distinct dimensions of WOM: volume and dispersion. They define dispersion as "the extent to which product-related conversations are taking place across a broad range of communities" (p. 546). They find that in the context of new TV shows, more newsgroups engaging online conversations on the given topic has more impact on ratings, but that this impact decreases over time. When online WOM about a product recall crisis appears across more social media platforms, more current and potential consumers receive negative recall information, increasing investors' uncertainty about the future earnings of the company and, in turn, decreasing stock returns. WOM spreads quickly under the same social media platform where people receive information by interacting frequently with each other (Mohr & Nevin, 1990). On the other hand, while information spreads slowly across platforms (Putsis, Balasubramanian, Kaplan, & Sen, 1997), it is likely to reach more people. Therefore, holding the amount of information constant, more people will be informed about a product recall announcement if online chatter occurs across social media platforms, increasing investors' concerns about the future earnings of the company. Therefore, we expect that:

H_4. The negative impact of a product recall crisis on abnormal returns is larger when the breadth of online WOM increases.

Companies are using the Internet to disseminate information about their financial performance as a means to market their companies to shareholders and investors (Debreceny, Gray, & Rahman, 2002). Company response tactics substantially influence the consequences of a crisis and, as a result, drive firm value after a product recall crisis (Chen et al., 2009; Siomkos & Kurzbard, 1994). For example, in the context of the automobile industry, Piracha, Romeo, and Weinberger (1991) find that a company response following negative publicity can limit damage in terms of detrimental sales impact. Furthermore, according to signaling theory, positive firm response to a product recall crisis is also viewed as evidence of the company's commitment to the brand (Dawar, 1998). A company may reverse consumers' fears of helplessness and uncertainty in a crisis situation when it is willing to share information across social media platforms and deal with the crisis in an open and transparent manner (Pearson & Clair, 1998). In addition, Blankespoor, Miller, and White (2014) find that firm dissemination of press releases on Twitter is associated with lower bid-ask spreads, consistent with decreased information asymmetry. Therefore, a company's involvement in social media can moderate product recall crisis effects. Overall, we hypothesize the following:

H_5. The negative impact of a product recall crisis on abnormal returns is lower when the company engages in social media surrounding the event.

2.2. Interaction Between Social Media and Brand Equity

In addition to examining the effects of social media in a product recall crisis, we consider how online WOM's impact on firm value is moderated by brand equity. In this study, we call brands with higher brand equity in the form of reputation *strong* brands and brands with lower brand equity *weak* brands (Aaker 2004). Strong brands can increase a firm's profits and reduce the vulnerability of cash flow by signaling high-quality offerings (Aaker & Jacobson, 1994; Erdem & Swait, 1998). Strong brands are less susceptible to the harmful effects of company crisis events (Aaker, 1996). However, the current Web 2.0 environment may disturb this "insurance-like" protection of shareholder value. Thus, the question is whether strong brands can mitigate the threats posed by negative social media metrics. To be specific, we consider whether the negative effects of the volume and valence of online WOM on firm value in a product recall crisis are asymmetric between strong brands and weak brands, as shown in Figure 1.

One explanation for why the volume of online WOM has been shown to influence product sales is the awareness effect (Dhar & Chang, 2009; Duan, et al., 2008). On the negative side, exposure to large amounts of information in a crisis may increase investor concerns related to its potential negative impact, leading investors to overreact. This overreaction results in high variation of stock returns (Antweiler & Frank, 2004). On the positive side, Cleeren, van Heerde, and Dekimpe (2013) have recently shown that increased media attention in a product recall crisis can increase the effectiveness of brand advertising, leading to a higher return on advertising investment.

However, this effect may not be consistent for both strong brands and weak brands. Consumers often try to assign whom or what is responsible for the cause of negative events (Weiner, 2000). If consumers believe that the company is primarily responsible for the product failure, they blame the company and desire to hurt the firm's business (Folkes, 1984). Laczniak, DeCarlo, and Ramaswami (2001) found that consumers are less likely to attribute the responsibility of a crisis to a company with a familiar and favorable brand. Conversely, a less favorable or relatively unknown brand generates complaints, which are more often attributed to the company (Mowen, 1980). Weak brands are more likely to take the blame for a product recall crisis, and therefore the effectiveness of advertising should be less than for strong brands (Cleeren, et al., 2013). With the particular benefits of the attribution effect for strong brands, we expect cash flow advantages to accrue for strong brands but not for weak brands. Therefore, we hypothesize that:

H_6. The negative effect of the volume of online WOM on abnormal returns is larger for weak brands than strong brands.

In general, negative WOM has shown to hurt product sales (Basuroy, et al., 2003; Chevalier & Mayzlin, 2006; Goldenberg, Libai, Moldovan, & Muller, 2007) and to decrease firm value (Luo, 2009; Tirunillai & Tellis, 2012). However, the negative impact may not be uniform for all brands. Ahluwalia, Burnkrant and Unnava (2000) find that low brand-commitment consumers tend to treat negative publicity as more diagnostic than positive information about a brand. However, consumers who have a high commitment to a brand are likely to process publicity information in a biased manner and mount counterarguments against negative information about the brand. Consumers with strong brand attitudes are likely to resist the impact of negative publicity, whereas consumers with weak brand attitudes tend to exacerbate the negative effect (Pullig, Netemeyer, & Biswas, 2006). From the perspective of the financial market, brand equity is a valuable, intangible asset that can effectively reduce the volatility and vulnerability of cash flow by differentiating firms' offers, enhancing loyalty and stabilizing demand (Keller & Lehmann, 2006). A strong brand can grant protection from equity dilution in the case of product failures and, thus, reduce variability in future cash flow (Rego, et al., 2009). In summary, a firm builds a strong brand not for what it can do today but for the protection it provides in the face of inevitable crisis events. Thus, we hypothesize the following:

H_7. The negative effect of the valence of online WOM on abnormal returns is larger for weak brands than for strong brands.

H_6 and H_7 provide formal hypotheses related to the interaction of brand equity with volume and valence. We do not, however, offer formal hypotheses related to the interaction of brand equity with two other proposed social media metrics, growth and breadth. As mentioned above, growth and breadth are relatively new social media metrics in the literature and, thus, the direction of their moderating interaction of brand equity is unclear. For example, breadth may provide the particular benefits of the awareness effect for weak brands by exposing more individuals in different domains to the product recall. However, breadth may also hurt weak brands more due to the negative effect in terms of stock performance under product recalls by coverage over a wider spectrum of platforms. We, therefore, do not offer a directional hypothesis on these grounds and instead present exploratory results for these interactions[1].

3. Research Methodology

3.1. Event Study Analysis

Since Fama et al. (1969) introduced the event study methodology, it has become the standard method for investigating investor community reaction to an announcement or other information event. The primary performance measures in this study are abnormal returns and cumulative abnormal returns over an event window centered on the product recall announcement. This practice permits examination of periods surrounding the event by calculating cumulative abnormal returns and captures the lagged impact of the announcement on securities' prices, which occur after the stock market closes on the announcement day. This process also allows for information leakage prior to the event day, and assumes that the stock market absorbs all information completely with regards to the announcement after the event day (McWilliams & Siegel, 1997).

Daily stock return data is obtained from the Center for Research in Security Prices (CRSP) at the University of Chicago and Yahoo! Finance. The abnormal return is the actual stock return over the event window minus the expected return of the firm. In line with Brown and Warner's (1985) approach in event study analysis, the market model is applied to obtain estimates of expected returns. To capture the effect of the event on

[1] We thank an anonymous reviewer for suggesting inclusion of these additional interactions in our model.

company i, we first estimate stock returns of firm i on day t based on the market model by using a period of 250 days which are from 267 to 17 days prior to the event, preventing any potential bias (Fama et al., 1969):

(1) $$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$$

where R_{it} is the daily return of firm i on day t, R_{mt} is the daily return of a market portfolio of stocks on day t, and β_i is the systematic risk of firm i. For the return of a market portfolio of stocks, we use the value-weighted return on all NYSE, AMEX, and NASDAQ stocks, as reported in the Fama/French Data Library and CRSP. In the next step, we measure abnormal returns as the difference between the actual return and the estimated return in the following equation:

(2) $$AR_{it} = R_{it} - E(R_{it}) = R_{it} - (\hat{a}_i + \hat{b}_i R_{mt})$$

where $\hat{a}_i$ and $\hat{b}_i$ are the ordinary least squares estimated parameters obtained from Equation 1.

It is important in an event study to examine the cumulative abnormal returns surrounding the event in several intervals for two reasons. First, this captures possible uncertainty regarding the actual date of the event. Second, it allows researchers to examine the cumulative effect of an event, which may be spread over several days, after the event (Gielens, Van de Gucht, Steenkamp, & Dekimpe, 2008). There exists evidence that product recall announcements have cumulative effects on manufacturers beyond the actual event day (e.g., Jarrell & Peltzman, 1985). We calculate the cumulative abnormal returns that are the aggregate of the abnormal returns for a firm over the event window [t_1, t_2] to examine the overall influence of the recall event:

(3) $$CAR_i\left[t_1, t_2\right] = \sum_{t=t_1}^{t_2} AR_{it}$$

We examine whether and how the investor community reacts to a product recall announcement on the event day by applying two parametric statistical tests to establish the robustness of results: traditional cross-sectional t-test (Brown & Warner, 1985) and the BMP test (Boehmer, Masumeci, & Poulsen, 1991). We also apply one non-parametric test: the Wilcoxon rank-sum test, which makes a less restrictive assumption of normality and is commonly used in previous literature that considers both the magnitude and the sign of standardized abnormal returns (Myron, Sushka, & Polonchek, 1993).

To examine the moderating effects of social metrics, company social media strategy, and brand equity on cumulative abnormal returns, we estimate an empirical model that includes a set of explanatory variables and control variables:

(4) $$\begin{aligned} CAR_i = \alpha_0 &+ \beta_1 Volume_i + \beta_2 Valence_i + \beta_3 Growth_i + \beta_4 Breadth_i + \beta_5 ComInv_i \\ &+ \beta_6 Brand_i + \beta_7 (Volume * Brand)_i + \beta_8 (Valence * Brand)_i \\ &+ \beta_9 (Growth * Brand)_i + \beta_{10} (Breadth * Brand)_i \\ &+ \beta_{11} Units_i + \sum_{h=1}^{2} \beta_{12,h} Severity_{ih} + \sum_{j=1}^{5} \beta_{13,j} Category_{ij} \\ &+ \beta_{14} Frequency_i + \beta_{15} Size_i + \beta_{16} OM_i + \beta_{17} Leverage_i + \varepsilon_i \end{aligned}$$

where CAR_i is cumulative abnormal returns of firm *i* (see Equation 3), *Volume*, *Valence*, *Growth*, and *Breadth* clarify the social media metrics within the event window in terms of volume of online WOM, proportion of negative online WOM, growth rate of online WOM, and breadth of online WOM. *ComInv* denotes company social media involvement. *Brand* denotes brand equity. *Volume*Brand*, *Valence*Brand*, *Growth*Brand*, and *Breadth*Brand* denote interaction effects between brand equity and the volume, valence, growth, and breadth of online WOM, respectively. Control variables of product recall characteristics include recalled product units (*Units*), level of severity of the crisis (*Severity*), and product category (*Category*). Control variables of firm-level characteristics include number of product recalls (*Frequency*), firm size (*Size*), operating margin (*OM*), and financial leverage (*Leverage*).

3.2. Data and Measures

The focal event in this study is the product recall announcement with the event day defined as the date when the U.S. Government officially announces the product recall. We collected product recall data from USASearch's Product Recall Data which aggregates from three federal government agencies: Centers for Disease Control and Prevention (CDC), National Highway Traffic Safety Administration (NHTSA), and Consumer Product Safety Commission (CPSC). To build the database, we collected product recall events from December 2010 through February 2012. During this period there were 2,124 product recall events: 918 food and drug safety recalls were from the CDC, 808 car safety recalls were from the NHTSA, and 398 product safety recalls were from the CPSC. Given study objectives tied to stock performance, we restricted the selection of information product recall announcements to those of publicly traded companies with common stocks listed on either the New York Stock Exchange (NYSE) or the National Association of Securities Dealers Automated Quotations (NASDAQ). This criterion resulted in a sample of 346 product recall announcements. We then excluded 43 recall announcements issued by retailers such as Target, Walmart, and Big Lots in which the products recalled bear the manufacturer's name instead of the retailer's. In this case, only a tiny portion of the negative effects of any given recall is expected to accrue to the distribution companies whereas the manufacturers of recalled products bear most of the negative effects (Pruitt & Peterson, 1986). We also excluded 65 business-to-business cases as these cases differ considerably from business-to-consumer cases in terms of product recall effects and social media patterns. An additional 18 recalls were eliminated due to the overlap for separate recall events by the same manufacturer. Time interval overlap events make it difficult to determine the market's reactions to each individual event accurately (Pruitt & Peterson, 1986).

To minimize further the effect of confounding events, we eliminated 35 observations where the release of the product recall announcement coincided with other potentially confounding announcements such as earnings announcements, news about changes in the executive board, mergers and acquisitions disclosures, and restructuring announcements, as these events also manifest effects on shareholder value (e.g., Clement, Frankel, & Miller, 2003). We searched the *Wall Street Journal Index,* regarded as the most comprehensive resource of financially relevant news, to identify if a given event was contaminated (McWilliams & Siegel, 1997). Table 1 categorizes the other potential significant news and company announcements found on the *Wall Street Journal Index* during the same day of product recall announcements. In sum, the final sample consists of 185 product recall announcements.

--- Insert Table 1 about here ---

Summary statistics of the final sample of 185 product recall announcements are presented in Table 2. Panel A presents the final sample in the six industry categories applied by Pruitt and Peterson (1986) and Chu et al. (2005). Of the six categories, the rubber/automotive parts category has the largest number of recalls in the sample at 40 percent which is consistent with the evidence that product recalls in the automobile industry are more frequent than in other industries (Chen et al., 2009; Davidson & Worrell, 1992). Panel B categorizes the recalls by market capitalization of the recalling companies. As shown in Panel B, large firms with market capitalizations greater than $5 billion make up the majority of the affected companies (59 percent). Their dominant representation in the sample is similar to Pruitt and Peterson's (1986) and Chu et al.'s (2005) sample. Panel C shows the severity of product recalls from high (Class I) to low (Class III), by following the CPSC guideline of categorizing hazards (*U.S. Consumer Product Safety Commission*, 2012). Most recalls are classified as low hazard (Class III) at 44 percent whereas 22 percent of recalls in the sample represent high hazard (Class I). Panel D describes the number of product recall announcements for the sample firms. Most companies (70 firms) in the sample have only one recall announcement during the time period investigated. Overall, product recalls are widespread across industries and occurrence of product recalls in any one specific firm is infrequent.

--- Insert Table 2 about here ---

We collected social media metrics data by purchasing the Alterian SM2 program, a leader in campaign management and social media analytics. SM2's data warehouse has an extensive dataset with historical data containing over 20 billion social media mentions, blogs, tweets, posts, images and conversation. This enabled us to collect social media metric data during the research period. We chose a 15-day event window [-7, 7] as the time length to collect social media metrics data since in practice, researchers who applied event study to examine product recall effects found that the recall impact is captured within this time length. For example, Jarrell and Peltzman (1985) found that [-4, 5] event window yields the most loss by examining different event window lengths. Similar to

Jarrell and Peltzman's (1985) finding, Thomsen and McKenzie (2001) found that the most adverse stock price movement occurs within six trading days after the product recall announcement date. In sum, using a [-7, 7] event window as the initial step to collect social media metrics data would be long enough to capture the lagged effect. In total, the dataset contains 89,279 online posts regarding 185 product recall announcements during a 15-day event window [-7, 7]. The measures of four social media metrics (i.e., volume, valence, growth rate, and breadth) and company social media involvement are explained in our next section and summarized in Table 3, Column 2.

--- Insert Table 3 about here ---

Volume is measured as the total number of posts related to the product recall of a firm within the event window. This measure reflects the magnitude of the awareness of recall in online WOM. The sentiment of each post is provided by the Alterian SM2 program. The program identifies positive and negative words based on a single, unweighted lexicon in the dictionary to determine sentiment by evaluating the full balance of positive and negative words in an entire post. The total number of positive words versus negative words is charted out on a five point Likert scale, classified from very negative (*VN*), somewhat negative (*SN*), neutral, somewhat positive (*SP*), to very positive (*VP*). The valence of online WOM is measured as the ratio of the total number of negative posts (i.e., $VN + SN$) to the total number of valence posts which include both positive posts (i.e., $VP + SP$) and negative posts (i.e., $VN + SN$) about the product recall of a firm within the event window. The concept of compound growth rate is applied to measure how online WOM grows on average per day when a company announces a product recall, after considering the effects of compounding. Breadth is measured as the number of different social media platforms that register recall-relevance within the event window. To calculate this metric, the source of each post is identified and then classified into different platforms. The number of platforms is then counted to reflect the magnitude of coverage evident in online WOM. Company social media involvement is determined by whether a given company has participated in the crisis conversation via an active presence on the company website, a company blog, Twitter, Facebook page, or other social media sites.

In this study, we operationalize brand equity by measuring brand reputation using Fortune's annual survey of Most Admired Companies (FMAC) in light of past research (Barber et al. 2003, Basdeo et al. 2006, Chen et al., 2009. Walker 2010). Brand reputation captures the affective component typically included in measures of brand equity strength (Aaker 2004). We identified those brands that appeared on the FMAC list as least once from 2009, 2010, 2011 and 2012 (our research period) as strong brands. In line with previous work (Mishina et al. 2010, Tavassoli et al. 2014), we created a dichotomous variable that took the value 1 to capture presence of a brand on the FMAC list and 0 otherwise.

We include product recall characteristics and firm-level characteristics as control variables. Product recall characteristics include total units of the product to be recalled, the level of severity of the crisis, and the product category, all influencing abnormal returns in different ways. As expected, a small volume of the recalled product induces lower recall costs (Chen et al., 2009). Cheah et al.'s (2007) examination of pharmaceutical product recalls supports that investors penalize firms more when product defects are more dangerous. Researchers empirically find that product categories significantly influence abnormal returns in product recall events (Chu et al., 2005; Pruitt & Peterson, 1986). We also control for firm-level characteristics that might influence how investors react to a product recall announcement: number of product recalls, firm size, operating margins, and financial leverage. Based on attribution theory, a history of crises increases attributions of crisis responsibility and thus, has a direct negative effect on firm value (Coombs, 2004). Recalls by small size firms (i.e., small market capitalization) have been shown to cause greater negative effects on returns than large size firms (i.e., large market capitalization) that may buffer the firm from the product recall crisis (Salin & Hooker, 2001). We also control for operating margins since they influence stock returns and are valued by shareholders (Pauwels, Silva-Risso, Srinivasan, & Hanssens, 2004). Financial leverage affects investors' response to the crisis since this leverage increases investors' concerns regarding consequences of the product recall (Chen et al., 2009). Table 3 summarizes variable operationalizations and data sources.

4. Empirical Results

4.1. Event Effect

Following Brown and Warner's (1985) study, this study calculates the estimated returns by using the parameters of the market model (Equation 1) for each firm, and regressing its actual returns on the returns of a weighted portfolio of stocks during the estimation period of 250 days (t-267 to t-17 days relative to the event day t). The estimated returns were then used in Equation 2 to estimate abnormal returns for 185 product recall announcements on and around the event day. Figure 2 presents the distribution of abnormal returns and standardized abnormal returns, respectively, on the event day for product recall announcements.

--- Insert Figure 2 about here ---

Table 4 presents the average abnormal returns for the 185 product recall announcements on the event day, as well as for a window of [-7, 7] days around the event day. The results indicate that, on average, firms experienced a significant loss of -.237% ($p < .05$) in abnormal returns when they announced product recalls. This estimate has the similar order of magnitude as abnormal returns reported in other product recall event studies. For example, Pruitt and Peterson (1986) report -.4% abnormal returns and more recently, Rupp (2004) reports a -.12% abnormal returns due to automotive recall announcements. Furthermore, companies experienced an average impact of -.188% abnormal returns on Day -1, which is close to significance ($p < .10$), indicating evidence of information leakage before the announcement.

In addition to the traditional cross-sectional t-test, as shown in Column 3 of Table 4, this study performed an additional BMP (1991) test, which is robust to potential event-induced changes in variance, to further examine the significance of the results. As shown in Table 4, Column 4, the t-value of the event day (Day 0) derived from this test is -2.20 ($p < .05$), which is statistically significant. This study also applied the Wilcoxon non-parametric test and the result further confirms the significance of negative abnormal returns on the event day, as indicated in the last column. Overall, the negative abnormal returns with the announcement of a product recall are consistently significant in the traditional cross-sectional t-test, the BMP test, and the non-parametric Wilcoxon rank-sum test.

--- Insert Table 4 about here ---

In product recall announcement event studies or other marketing-related event studies, it is standard practice to examine the cumulative average abnormal return for various windows surrounding the event day (Agrawal & Kamakura, 1995; Gielens, et al., 2008). Table 5 presents the cumulative average abnormal return (CAAR) for various windows surrounding the event day. Of all windows considered, three windows show a significant CAAR. The total average effect over Days -2 and 0 (i.e., [-2, 0]) is significant, with a value of -.456% ($p < .05$) as well as Days -1 and 0 (i.e., [-1, 0]), with a value of -.426% ($p < .05$). The window from Days -1 to 1 (i.e., [-1, 1]) also shows a significant CAAR ($p < .10$) and amounts to -.453%. There are no significant cumulative effects after Day 1. As such, results of significant negative abnormal returns on the event day and the cumulative average abnormal return over 3 days (including Day 0) suggest a fast adjustment in shareholder value following a product recall announcement. The shorter event window with significant effects and the absence of significant cumulative effects beyond the 3-day period are in line with the presumed efficiency of the stock market (Fama, et al., 1969).

--- Insert Table 5 about here ---

Unlike prior event studies that examine moderating factors that are static over the time window such as firm characteristics and marketplace characteristics (Gielens et al. 2008; Raassens et al. 2014), our study examines the moderating effect of social media whose magnitude varies over the time window. Thus, we utilize the [-1, 1] time window as we are primarily interested in testing the moderating effects of social media metrics and brand equity on stock price performance. As discussed above, we document a significant, negative CAAR for the [-2, 0], [-1, 0], and [-1, 1] event windows. The results are similar for the three windows, but we focus on the [-1, 1] window because the level of social media information is not known with precision until the day after the company makes the recall. The reaction to the recall itself cannot be predicted by the market and in fact may be quite difficult to incorporate given its diffused and dynamic nature. The inclusion of Day +1 is important since significant social media activity at Day +1 provides the market with additional information to observe and incorporate. This is also in line with prior event study research that has used time windows which are less significant but more relevant to the theoretical arguments they are interested in exploring (Wiles & Danielova 2009). Thus, to investigate the moderating effects of social media on abnormal returns, we believe that [-1, 1] is a more empirically and theoretically appropriate window given the nature of the data we collected and the characteristics of the moderators of interest. The effects of social media metrics on stock performance during the product recall announcement are likely to be fully captured after the event date. Therefore, to examine the moderating effects of social media metrics, company social media strategy, and brand equity, we measured these focal independent variables in the 3-day event window [-1, 1] and estimated Equation 4 with the individual firm's CAAR [-1, 1] as the dependent variable.[2]

Table 6 provides descriptive statistics and a correlation matrix of independent variables in regard to the event window [-1, 1]. The mean of the number of online WOM is 252.32 messages for each product recall event. About 57 percent of online WOM are classified as negative sentiment. On average, the growth rate is 46 percent. That is, suppose there are 100 total comments in the first day, this will translate to 146 total

[2] We document a significant, negative CAAR for the [-2, 0], [-1, 0], and [-1, 1] event windows and choose [-1, 1] to test our hypotheses. Our findings are not robust to the two other windows. However, this failure to demonstrate robustness, we argue is due to the unique nature of social media and its effect on stock price.

comments in the next day. The descriptive statistics of the breadth of online WOM suggests that the media coverage is strong, given that the average is 4.86 out of 6, the maximum coverage. Regarding company involvement, around 18 percent of the sample (i.e., 34 events) has company involvement in the social media during a product recall crisis. Table 7 presents the estimation results of the moderator analysis.

--- Insert Table 6 and 7 about here ---

4.2. Social media effects

In order to reduce multicollinearity produced by four interaction terms in the model, we standardized four continuous social media metrics by mean-centering (subtracting the mean from each variable) (Aiken and Stephen 1991). As shown in Table 7, the effect of the volume of online WOM has the expected negative impact on abnormal returns and is marginally significant (β_1 = -.004, p < .1) in support of H_1. Thus, investors perceive higher volume of online WOM as negative for an affected company. The valence of online WOM has a significantly negative effect on abnormal return (β_2 = -2.722, p < .01), which provides support for H_2. The higher proportion of negative online WOM is found to exacerbate the negative impact of a product recall crisis on firm financial value. This is in line with Luo's (2009) finding that negative WOM has a short-term, immediate negative impact on stock returns. Accordingly, these findings suggest that investors are influenced by both an awareness effect and a persuasive effect generated by online WOM. Not only does the valence of online WOM negatively affect abnormal returns, but the growth rate of online WOM also exacerbates the negative effects of product recall crises on stock returns (β_3 = -1.486, p < .01), in support of H_3. Counter to our hypothesis, the effect of the breadth of online WOM (H_4) on abnormal returns is significant but positive (.703, $p < .05$). Though we had predicted a negative relationship we offer several post hoc explanations for this result. When online WOM about a product recall crisis is concentrated on a single social media platform, the current and potential consumers on that social media platform receive negative recall information repeatedly, resulting in more negative attitude toward the product recall crisis. This focused attention magnifies investors' trepidation about the future earnings of the company, and in turn decreases stock returns. In other words, under the same amount of information, people may be less affected by a product recall announcement if online WOM spreads out over various social media platforms. We feel this finding warrants further investigation. Also surprisingly, we find that company involvement in social media strategy does not have a significant effect on abnormal returns (β_5 = -.888, $p > .1$) thus failing to confirm H_5. We discuss these findings further in our discussion section.

4.3. Interaction effects between social media and brand equity

As expected, the results of two interaction effects indicate that online WOM's impact on firm value is moderated by strong versus weak brands. In the case of the volume of online WOM, the negative effect of the volume of online WOM on abnormal returns is larger for weak brands than for strong brands (β_6 = .004, $p < .1$). This finding suggests that strong brands can resist the negative effect of the volume of online WOM. Conversely, the larger volume of online WOM hurts weak brands because they take more blame for the crisis, decreasing the effectiveness of advertising (Cleeren, et al., 2013). In order to gain a better understanding of interaction effects, we conduct a marginal effect analysis to assess the volume of online WOM effects across strong versus weak brands[3]. The marginal effect of volume of online WOM on abnormal returns is negative and significant (-.004, $p < .1$) for weak brands but not significant for strong brands (.0003, $p > .1$). In the case of the valence of online WOM, the negative effect of the valence of online WOM on abnormal returns again is greater for weak brands than for strong brands ($\beta_7 = 3.944$, $p < .01$). The further marginal effect analysis shows that for weak brands, the marginal effect of valence of online WOM is negative and significant (-2.722, $p < .01$) while for strong brands, the marginal effect is positive but non-significant (1.222, $p > .1$). These findings indicate that weak brands suffer more from negative online WOM whereas strong brands are more resilient to product recall crises when the proportion of negative online WOM is higher. Overall, the support of H_6 and H_7 highlight the importance of building brand equity for a firm, confirming that brand equity is a valuable, intangible asset (Keller & Lehmann, 2006).

In regards to our non-hypothesized interactions we find that in the case of the breadth of online WOM, the negative effect of breadth of online WOM on abnormal returns is larger for strong brands than for weak brands ($\beta = -1.289$, $p < .05$). This finding suggests that weak brands with lower awareness may benefit from media coverage due to the increased visibility, enhancing consumers' consideration sets and increasing adoption rates (Vermeulen and Seegers 2009). Moreover, WOM is primarily beneficial to the extent that it results in the spread of information as opposed to influence or persuasion (Godes and Mayzlin 2009). In contrast, there might have been a ceiling effect because

[3] We thank an anonymous reviewer for suggesting marginal effect analysis for confirmation. We perform marginal effect analysis using "margins" procedure in STATA 13.

strong brands are already saturated at high awareness. In the case of the growth of online WOM, we find no significant moderating effect of brand equity ($\beta = 1.051$, $p > .1$).

4.4. Robustness Check

This study assesses the robustness of the findings to various issues: (i) the interaction effect of the severity, (ii) the subset of firms with only one recall, and (iii) the alternative measure of the breadth of online WOM. We report these results in the third, fourth, and fifth columns in Table 8, respectively.

--- Insert Table 8 about here ---

First, the social media metrics seem to vary significantly depending on the levels of severity of product recall crises. Therefore, we assess the severity effect by including interaction terms between social media metrics and the severity. Given that there are three levels of severity, we include eight interaction terms between four social media metrics (i.e., volume, valence, growth rate, and breadth) and two dummy variables indicating the severity of recalls in the model. As shown in Table 8, the findings remain robust and none of the interaction terms between social media metrics and severity of product recalls is significant ($p > .1$). Therefore, the parsimonious focal model is preferred.

Second, several companies have multiple product recalls during the study time period as shown in Table 2, Panel D. Multiple recall events in a short time period may possibly contaminate the estimation window, leading to biased estimated returns and consequently abnormal returns. In fact, if companies have more than one recall over the study time period, it becomes hard to assess the isolated impact of a particular product recall crisis. To examine whether the multiple events issue affects the main findings, we use a subsample of companies with one product recall. If a company has more than one recall announcement, only the first product recall announcement is included in the subsample to examine social media effects and brand equity effects on firm value during a product recall crisis. Again, as shown in Table 8, the findings are mostly robust related to this issue.

Finally, we broaden our operationalization of the breadth of online WOM. The measure of breadth of online WOM in the focal model is to classify more than 80,000 online WOM into six aggregate social media platforms (i.e., message/board forum, microblog, blog, social network, video/photo sharing, and media types-other). However, each aggregate social media platform includes different kinds of channels; for example, blog platforms include political blogs, mommy blogs, business blogs, and health blogs. Thus, we further classify each online WOM platform into specific social media websites by looking at their uniform resource locators (URLs) for each product recall event to examine the impact of the breadth of online WOM on firm value. As shown in Table 8, using individual-level measure of breadth is largely robust to the findings based on the aggregate-level measure.

5. Conclusions and Implications

Despite widespread recognition that a product recall crisis troubles future sales growth and hurts stock performance, there is limited conceptual or empirical research that systematically addresses factors that moderate such negative effects. Particularly, the extant research of product-harm crises has yet to consider the negative impact of a product recall on firm value within a contemporary social media driven world. In order to gain a comprehensive understanding of product recall phenomena and successfully overcome a crisis in the digital era, this study leveraged a sample of 185 product recall events from year 2010 to year 2012 to explore the role of social media metrics and brand equity on firm valuation. This study offers theoretical contributions and managerial implications in the context of crisis management in Web 2.0 for academics and practitioners.

The focal measure of performance in this study is shareholder value, which has been recognized as an important metric for evaluating marketing and branding activities (Srinivasan & Hanssens, 2009). The framework offers a more refined perspective on the online WOM-firm value link that provides diagnostic insight into whether social media can hurt or help a company's shareholder value in the event of a product recall crisis. This study contributes to online WOM theory more generally by identifying and operationalizing four different dimensions of social media activities: volume, valence, growth rate, and breadth. Research on online WOM tends to focus on the volume and the valence effects but overlooks the role of growth and dispersion across multiple platforms. Our findings distinguish different dimensions of social media and identify the damage such threats have on a company announcing a product recall. Our empirical findings reveal that the more negative the online WOM about a product recall is, the lower the stock returns. Furthermore, the faster growth of online WOM magnifies the negative impact of product recall crises on stock returns.

This study also explored whether a company's engagement in social media can mitigate the negative impact of product recall crises. Though there exists case based (Dean 2004; Kurzbard and Siomkos 1992; Laufer and Coombs 2006), and experimental work (Dutta and Pullig 2011; Siomkos and Kurzbard 1994) examining these effects, to our knowledge this paper is the first empirical study to examine the moderating role of such involvement on shareholder value. Our results show no significant effect on company engagement, raising some interesting managerial implications. In the online environment, company responses may simply get lost given the volume of online WOM. Companies may also choose to downplay the significance of such recalls by not formally acknowledging them. Only 18 percent of the companies in our study engaged in online conversations following product recalls. One possible explanation for this is that most product recalls are not the result of serious widespread consumer danger as in the Toyota recall case. As a result, affected companies may choose to passively manage a product recall. Indeed, as in Chen et al.'s (2009) conclusion, a proactive product recall strategy may lead to a more negative effect on firm value than a passive product recall strategy. A classic marketing article regarding a firm's reactions to adverse rumors (Tybout, Calder, Sternthal 1981) supports the legitimacy of such a strategy. Future work should examine the various types of company involvement and its potential interaction with varying levels of recall. Companies may be better served by trying to influence the valence or volume of social media rather than responding to the event itself. It may be prudent for the firm in only the most serious recalls to engage in dialogue. Other variables including the language, frequency, timing and source of the response may matter. These findings would have significant managerial import.

Though companies may be able to mitigate the effects of such crisis on their corporate reputation, efforts at mitigating short-term losses of shareholder wealth may be futile. Given the role consumers now play in disseminating knowledge, efforts by the firm to reply to product recall crises may be lost in the sheer volume of correspondence.

This is not to say that companies should not respond to these crises rather their impact on shareholder value may be viewed in the long term value such responses contribute to building brand equity.

This study also contributes to an understanding of the role of a brand in the Web 2.0 environment in the context of product recall crises. The findings suggest that strong brands are less affected by the negative effect of the volume of online WOM during a product recall event than weak brands. Since weak brands are likely to take the blame for a crisis, strong brands could take advantage of more online WOM to the extent that it results in higher advertising effectiveness (Cleeren, et al., 2013). In addition, the results show that a strong brand is more likely to withstand negative online WOM during product recall crises than a weak brand. Weak brands are more adversely affected by negative online WOM than strong brands. Overall, the findings show that a strong brand can grant protection from equity dilution and resist the impact of negative publicity in the case of product failures and, thus, reduce potential volatility in future cash flow.

While we provide new insight into the role of social media and brand equity during a product recall crisis, this study has some limitations that can be addressed by future work. The context for this study is the product recall crisis. It would be worthwhile to extend this study to other types of company crises, such as the BP oil spill or the Malaysian airlines flight 370 disappearance in which consumers' online WOM activities and company's engagement in online conversations are more enthusiastic.

This study focuses primarily on the impact of social media and the role of brand equity on firm value when a product recall is announced. Event studies are often limited in their ability to detect long-term effects on stock market performance. A focus on the abnormal stock market returns to the specific product recall announcement may not reveal how returns are distributed to the entire product recall process. Returns to the specific product recall announcement may be inflated or deflated because of multiple announcements in the product recall process. As such, alternative study methods such as using total market returns (Sood and Tellis 2009) that can detect and access possible long-term effects would be useful to complement this study. Furthermore, due to data availability limitations this study was not able to provide brand equity data at the daily level. Such data would be valuable and would provide opportunity to analyze the causality and short- and long-term relationships between online WOM, brand equity, and stock performance under a crisis event. Despite these limitations, we believe that our study provides a promising foundation for understanding the managerial implications of the product recall phenomenon. It is increasingly critical for firms to understand how the current Web 2.0 environment affects stock performance and to learn how to respond appropriately.

Reference

Aaker, D. A. (1996). *Building strong brands*. New York: Free Press.

Aaker, D. A. (2004). Leveraging the Corporate Brand. *California Management Review, 46*(3), 6-18.

Aaker, D. A., & Jacobson, R. (1994). The financial information content of perceived quality. *Journal of Marketing Research, 31*(2), 191-201.

Agrawal, J., & Kamakura, W. A. (1995). The economic worth of celebrity endorsers: An event study analysis. *Journal of Marketing, 59*(3), 56-62.

Ahluwalia, R., Burnkrant, R. E., & Unnava, H. R. (2000). Consumer response to negative publicity: The moderating role of commitment. *Journal of Marketing Research, 37*(2), 203-214.

Aiken, L. S., & Stephen, G. (1991). *Multiple Regression: Testing and Interpreting Interactions.* Newbury Park, CA: Sage Publications.

Antweiler, W., & Frank, M. Z. (2004). Is all that talk just noise? The information content of Internet stock message boards. *Journal of Finance, 59*(3), 1259-1294.

Ayres, C. (2009), "Revenge is best served cold - on YouTube," (accessed March 3, 2011), [available at http://www.timesonline.co.uk/tol/comment/columnists/chris_ayres/article6722407.ece].

Baker, W. E. (1999). When can affective conditioning and mere exposure directly influence brand choice? *Journal of Advertising, 28*(4), 31-46.

Barber, B. M., Heath, C., & Odean, T. (2003). Good Reasons Sell: Reason-Based Choice Among Group and Individual Investors in the Stock Market. *Management Science, 49*(12), 1636-1652.

Barwise, P., & Meehan, S. (2010). The one thing you must get right when building a brand. *Harvard Business Review, 88*(12), 80-84.

Basdeo, D. K., Smith, K. G., Grimm, C. M., Rindova, V. P., & Derfus, P. J. (2006). The impact of market actions on firm reputation. *Strategic Management Journal, 27*(12), 1205-1219.

Basuroy, S., Chatterjee, S., & Ravid, S. A. (2003). How critical are critical reviews? The box office effects of film critics, star power, and budgets. *Journal of Marketing, 67*(4), 103-117.

Berman, B. (1999). Planning for the inevitable product recall. *Business Horizons, 42*(2), 69-78.

Bickart, B., & Schindler, R. M. (2001). Internet forums as influential sources of consumer information. *Journal of Interactive Marketing, 15*(3), 31-40.

Blankespoor, E., Miller, G. S., & White, H. D. (2014). The role of sissemination in market liquidity: Evidence from firms' use of Twitter™. *Accounting Review, 89*(1), 79-112.

Boehmer, E., Masumeci, J., & Poulsen, A. B. (1991). Event-study methodology under conditions of event-induced variance. *Journal of Financial Economics, 30*(2), 253-272.

Brown, S. J., & Warner, J. B. (1985). Using daily stock returns : The case of event studies. *Journal of Financial Economics, 14*(1), 3-31.

Brownsell, A. (2010), "Toyota launches vehicle recall website as sales tumble," (accessed March 1, 2011), [available at http://www.marketingmagazine.co.uk/news/981338/Toyota-launches-vehicle-recall-website-sales-tumble/].

CBC News (2009), "Broken guitar song gets airline's attention," (accessed March 3, 2011), [available at http://www.cbc.ca/news/arts/music/story/2009/07/08/united-breaks-guitars.html].

Charoenrook, A., & Lewis, C. M. (2009). Information, selective disclosure, and analyst behavior. *Financial Management, 38*(1), 39-57.

Cheah, E. T., Chan, W. L., & Chieng, C. L. L. (2007). The corporate social responsibility of pharmaceutical product recalls: An empirical examination of U.S. and U.K. markets. *Journal of Business Ethics, 76*(4), 427-449.

Chen, Y., Ganesan, S., & Liu, Y. (2009). Does a firm's product-recall strategy affect its financial value? An examination of strategic alternatives during product-harm crises. *Journal of Marketing, 73*(6), 214-226.

Chen, Y., Liu, Y., & Zhang, J. (2012). When do third-party product reviews affect firm value and what can firms do? The case of media critics and professional movie reviews. *Journal of Marketing, 76*(2), 116-134.

Chevalier, J. A., & Mayzlin, D. (2006). The effect of word of mouth on sales: Online book reviews. *Journal of Marketing Research, 43*(3), 345-354.

Chu, T.-H., Lin, C.-C., & Prather, L. J. (2005). An extension of security price reactions around product recall announcements. *Quarterly Journal of Business & Economics, 44*(3/4), 33-48.

Clarkson, P. M., Joyce, D., & Tutticci, I. (2006). Market reaction to takeover rumour in Internet discussion sites. *Accounting & Finance, 46*(1), 31-52.

Cleeren, K., van Heerde, H. J., & Dekimpe, M. G. (2013). Rising from the ashes: How brands and categories can overcome product-harm crises. *Journal of Marketing, 77*(2), 58-77.

Clement, M., Frankel, R., & Miller, J. (2003). Confirming management earnings forecasts, earnings uncertainty, and stock returns. *Journal of Accounting Research, 41*(4), 653-679.

Coombs, W. T. (2004). Impact of past crises on current crisis communication. *Journal of Business Communication, 41*(3), 265-289.

Davidson, W. N., III, & Worrell, D. L. (1992). Research notes and communications: The effect of product recall announcements on shareholder wealth. *Strategic Management Journal, 13*(6), 467.

Dawar, N. (1998). Product-harm crises and the signaling ability of brands. *International Studies of Management & Organization, 28*(3), 109-119.

Dean, D. H. (2004). Consumer reaction to negative publicity. *Journal of Business Communication, 41*(2), 192-211.

Debreceny, R., Gray, G. L., & Rahman, A. (2002). The determinants of Internet financial reporting. *Journal of Accounting and Public Policy, 21*(4–5), 371-394.

Deighton, J. (2010). Social media and insurgency. In *Marketing Science Institute Board of Trustees Meeting: Embracing the Future*. Boston, MA.

Dellarocas, C., & Narayan, R. (2006). A statistical measure of a population's propensity to engage in post-purchase online word-of-mouth. *Statistical Science, 21*(2), 277-285.

Dhar, V., & Chang, E. A. (2009). Does chatter matter? The impact of user-generated content on music sales. *Journal of Interactive Marketing, 23*(4), 300-307.

Duan, W., Gu, B., & Whinston, A. B. (2008). The dynamics of online word-of-mouth and product sales—An empirical investigation of the movie industry. *Journal of Retailing, 84*(2), 233-242.

Dutta, S., & Pullig, C. (2011). Effectiveness of corporate responses to brand crises: The role of crisis type and response strategies. *Journal of Business Research, 64*(12), 1281-1287.

Erdem, T., & Swait, J. (1998). Brand equity as a signaling phenomenon. *Journal of Consumer Psychology, 7*(2), 131-157.

Fama, E. F., Fisher, L., Jensen, M. C., & Roll, R. (1969). The adjustment of stock prices to new information. *International Economic Review, 10*(1), 1-21.

Folkes, V. S. (1984). Consumer reactions to product failure: An attributional approach. *Journal of Consumer Research, 10*(4), 398-409.

Fournier, S., & Avery, J. (2011). The uninvited brand. *Business Horizons, 54*(3), 193-207.

Gaines-Ross, L. (2010). Reputation warfare. *Harvard Business Review, 88*(12), 70-76.

Gielens, K., Van de Gucht, L. M., Steenkamp, J.-B. E. M., & Dekimpe, M. G. (2008). Dancing with a giant: The effect of Wal-Mart's entry into the United Kingdom on the performance of European retailers. *Journal of Marketing Research, 45*(5), 519-534.

Godes, D., & Mayzlin, D. (2004). Using online conversations to study word-of-mouth communication. *Marketing Science, 23*(4), 545-560.

Godes, D., & Mayzlin, D. (2009). Firm-Created Word-of-Mouth Communication: Evidence from a Field Test. *Marketing Science, 28*(4), 721-739.

Goel, V. (2014), "G.M. Uses social media to manage customers and its reputation," (accessed March 28, 2014), [available at http://www.nytimes.com/2014/03/24/business/after-huge-recall-gm-speaks-to-customers-through-social-media.html?_r=0].

Goldenberg, J., Libai, B., Moldovan, S., & Muller, E. (2007). The NPV of bad news. *International Journal of Research in Marketing, 24*(3), 186-200.

Govindaraj, S., Jaggi, B., & Lin, B. (2004). Market overreaction to product recall revisited—The case of Firestone tires and the Ford Explorer. *Review of Quantitative Finance and Accounting, 23*(1), 31-54.

Gruen, T. W., Osmonbekov, T., & Czaplewski, A. J. (2006). eWOM: The impact of customer-to-customer online know-how exchange on customer value and loyalty. *Journal of Business Research, 59*(4), 449-456.

Hennig-Thurau, T., Gwinner, K. P., Walsh, G., & Gremler, D. D. (2004). Electronic word-of-mouth via consumer-opinion platforms: What motivates consumers to articulate themselves on the Internet? *Journal of Interactive Marketing, 18*(1), 38-52.

Iyengar, R., Han, S., & Gupta, S. (2009). Do friends influence purchases in a social network? In: Harvard Business School Working Paper, No. 09-123.

Jarrell, G., & Peltzman, S. (1985). The impact of product recalls on the wealth of sellers. *Journal of Political Economy, 93*(3), 512-536.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263-291.

Kalaignanam, K., Kushwaha, T., & Eilert, M. (2013). The impact of product recalls on future product reliability and future accidents: Evidence from the automobile industry. *Journal of Marketing, 77*(2), 41-57.

Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of Social Media. *Business Horizons, 53*(1), 59-68.

Keller, K. L., & Lehmann, D. R. (2006). Brands and branding: Research findings and future priorities. *Marketing Science, 25*(6), 740-759.

Kurzbard, G., & Siomkos, G. J. (1992). Crafting a damage control plan: Lessons from Perrier. *Journal of Business Strategy*, *13*(2), 39-43.

Laczniak, R. N., DeCarlo, T. E., & Ramaswami, S. N. (2001). Consumers' responses to negative word-of-mouth communication: An attribution theory perspective. *Journal of Consumer Psychology, 11*(1), 57-73.

Laufer, D., & Coombs, W. T. (2006). How should a company respond to a product harm crisis? The role of corporate reputation and consumer-based cues. *Business Horizons*, *49*(5), 379-385.

Liu, Y. (2006). Word of mouth for movies: Its dynamics and impact on box office revenue. *Journal of Marketing*, *70*(3), 74-89.

Luo, X. (2007). Consumer negative voice and firm-idiosyncratic stock returns. *Journal of Marketing*, *71*(3), 75-88.

Luo, X. (2009). Quantifying the long-term impact of negative word of mouth on cash flows and stock prices. *Marketing Science*, *28*(1), 148-165.

Mangold, W. G., & Faulds, D. J. (2009). Social media: The new hybrid element of the promotion mix. *Business Horizons*, *52*(4), 357-365.

Marsh, T. L., Schroeder, T. C., & Mintert, J. (2004). Impacts of meat product recalls on consumer demand in the USA. *Applied Economics*, *36*(9), 897-909.

McWilliams, A., & Siegel, D. (1997). Event studies in management research: Theoretical and empirical issues. *Academy of Management Journal*, *40*(3), 626-657.

Mishina, Y., Dykes, B. J., Block, E. S., & Pollock, T. G. (2010). Why “good” firms do bad things: The effects of high aspirations, high expectations, and prominence on the incidence of corporate illegality. *Academy of Management Journal*, *53*(4), 701-722.

Mohr, J., & Nevin, J. R. (1990). Communication strategies in marketing channels: A theoretical perspective. *Journal of Marketing*, *54*(4), 36-51.

Mowen, J. C. (1980). Further informaiton on consumer perceptions of product recalls. *Advances in Consumer Research*, *7*(1), 519-523.

Myron, B. S., Sushka, M. E., & Polonchek, J. A. (1993). The value of bank durability: borrowers as bank stakeholders. *Journal of Finance*, *48*(1), 247-266.

Nam, S., Manchanda, P., & Chintagunta, P. K. (2010). The effect of signal quality and contiguous word of mouth on customer acquisition for a video-on-demand service. *Marketing Science*, *29*(4), 690-700.

O'Reilly, C. A., III. (1982). Variations in decision makers' use of information sources: The impact of quality and accessibility of information. *Academy of Management Journal, 25*(4), 756-771.

Pauwels, K., Silva-Risso, J., Srinivasan, S., & Hanssens, D. M. (2004). New products, sales promotions, and firm value: The case of the automobile industry. *Journal of Marketing, 68*(4), 142-156.

Pearson, C. M., & Clair, J. A. (1998). Reframing crisis management. *Academy of Management Review, 23*(1), 59-76.

Piracha, A., Romeo, J. B., & Weinberger, M. G. (1991). Negative product safety news: coverage, responses, and effects. *Business Horizons, May-June*, 23-31.

Pruitt, S. W., & Peterson, D. R. (1986). Security price reactions around product recall announcements. *Journal of Financial Research, 9*(2), 113-122.

Pullig, C., Netemeyer, R. G., & Biswas, A. (2006). Attitude basis, certainty, and challenge alignment: A case of negative brand publicity. *Journal of the Academy of Marketing Science, 34*(4), 528-542.

Putsis, W. P. J., Balasubramanian, S., Kaplan, E. H., & Sen, S. K. (1997). Mixing behavior in cross-country diffusion. *Marketing Science, 16*(4), 354-369.

Raassens, N., Wuyts, S., & Geyskens, I. (2014). The performance implications of outsourcing customer support to service providers in emerging versus established economies. *International Journal of Research in Marketing, In-Press*.

Rego, L. L., Billett, M. T., & Morgan, N. A. (2009). Consumer-based brand equity and firm risk. *Journal of Marketing, 73*(6), 47-60.

Rooderkerk, R. P., & Pauwels, K. (2011). No comment?! The drivers of reactions to online posts in professional groups. *MSI Working Paper Series*, No. 11-116.

Rozin, P., & Royzman, E. B. (2001). Negativity bias, negativity dominance, and contagion. *Personality and Social Psychology Review, 5*(4), 296-320.

Rubel, O., Naik, P. A., & Srinivasan, S. (2011). Optimal advertising when envisioning a product-harm crisis. *Marketing Science, 30*(6), 1048-1065.

Rupp, N. G. (2004). The attributes of a costly recall: Evidence from the automotive industry. *Review of Industrial Organization, 25*(1), 21-44.

Rust, R. T., Ambler, T., Carpenter, G. S., Kumar, V., & Srivastava, R. K. (2004). Measuring marketing productivity: Current knowledge and future directions. *Journal of Marketing, 68*(4), 76-89.

Salin, V., & Hooker, N. H. (2001). Stock market reaction to food recalls. *Review of Agricultural Economics, 23*(1), 33-46.

Senecal, S., & Nantel, J. (2004). The influence of online product recommendations on consumers' online choices. *Journal of Retailing, 80*(2), 159-169.

Siomkos, G. J., & Kurzbard, G. (1994). The hidden crisis in product-harm crisis management. *European Journal of Marketing, 28*(2), 30-41.

Smith, R. E., & Vogt, C. A. (1995). The effects of integrating advertising and negative word-of-mouth communications on message processing and response. *Journal of Consumer Psychology, 4*(2), 133-151.

Sood, A., & Tellis, G. J. (2009). Do Innovations Really Pay Off? Total Stock Market Returns to Innovation. *Marketing Science, 28*(3), 442-456.

Srinivasan, S., & Hanssens, D. M. (2009). Marketing and firm value: metrics, methods, findings, and future directions. *Journal of Marketing Research, 46*(3), 293-312.

Tavassoli, N. T., Sorescu, A., & Chandy, R. (2014). Employee-Based Brand Equity: Why Firms With Strong Brands Pay Their Executives Less. *Journal of Marketing Research, In-Press*.

Thirumalai, S., & Sinha, K. K. (2011). Product recalls in the medical device industry: An empirical exploration of the sources and financial consequences. *Management Science, 57*(2), 376-392.

Thomsen, M. R., & McKenzie, A. M. (2001). Market incentives for safe foods: An examination of shareholder losses from meat and poultry recalls. *American Journal of Agricultural Economics, 83*(3), 526-538.

Tirunillai, S., & Tellis, G. J. (2012). Does chatter really matter? Dynamics of user-generated content and stock performance. *Marketing Science*.

Trusov, M., Bucklin, R. E., & Pauwels, K. (2009). Effects of word-of-mouth versus traditional marketing: Findings from an Internet social networking site. *Journal of Marketing, 73*(5), 90-102.

Tybout, A. M., Calder, B. J., & Sternthal, B. (1981). Using Information Processing Theory to Design Marketing Strategies. *Journal of Marketing Research*, *18*(1), 73-79.

U.S. Consumer Product Safety Commission (2012), "Recall Handbook," (accessed March 15, 2012), [available at http://www.cpsc.gov/businfo/8002.pdf].

Vermeulen, I. E., & Seegers, D. (2009). Tried and tested: The impact of online hotel reviews on consumer consideration. *Tourism Management*, *30*(1), 123-127.

Walker, K. (2010). A Systematic Review of the Corporate Reputation Literature: Definition, Measurement, and Theory. *Corporate Reputation Review*, *12*(4), 357-387.

Ward, James C., & Ostrom, Amy L. (2006). Complaining to the masses: The role of protest framing in customer-created complaint Web sites. *Journal of Consumer Research*, *33*(2), 220-230.

Weiner, B. (2000). Attributional thoughts about consumer behavior. *Journal of Consumer Research*, *27*(3), 382-387.

Wiles, M. A., & Danielova, A. (2009). The worth of product placement in successful films: An event study analysis. *Journal of Marketing*, *73*(4), 44-63.

Figure 1
Conceptual framework.

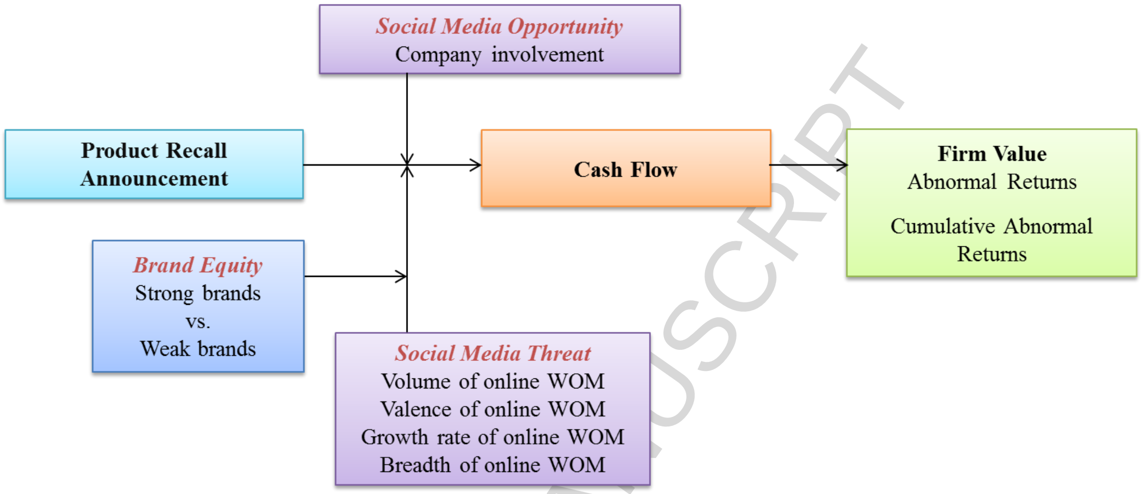
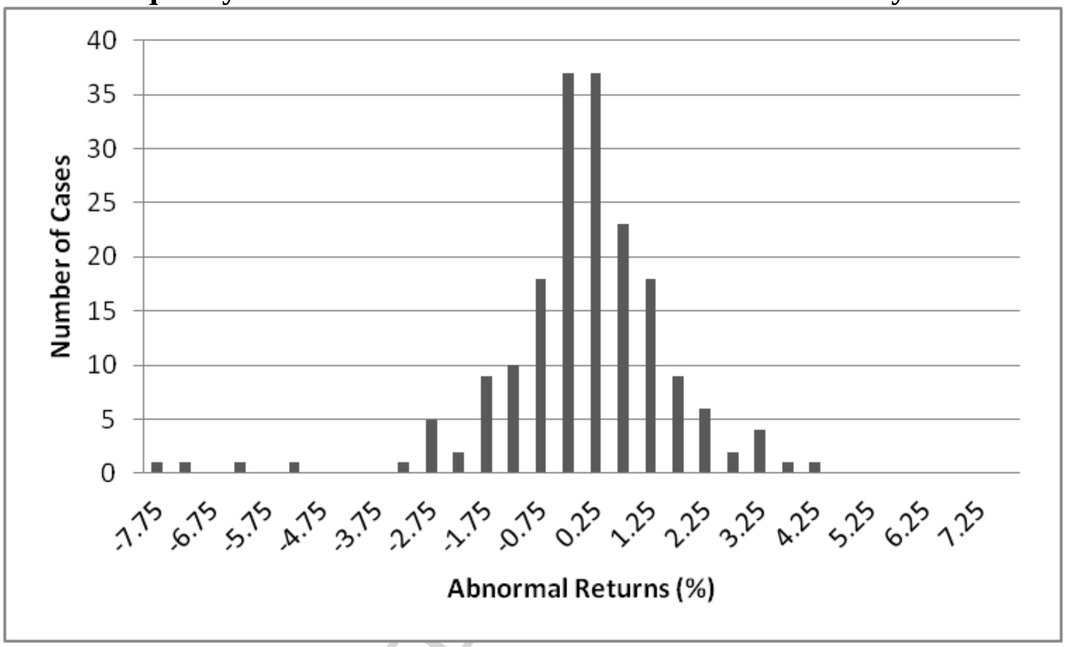


Figure 2
Distribution of abnormal returns.

Panel A: Frequency Distribution of Abnormal Returns on Event Day



Panel B: Frequency Distribution of Standardized Abnormal Returns on Event Day

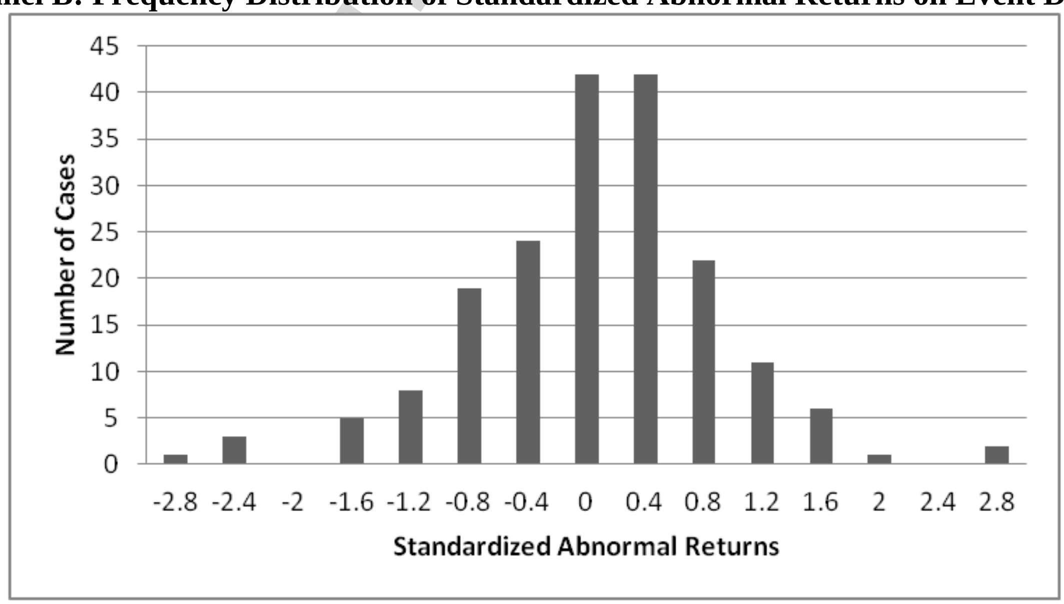


Table 1
Summary of potentially confounding announcements.

Type of Potentially Confounding Announcements	**Number of Observations**
Industry news	7
Product/Store/Factory announcement	6
Earnings announcement	8
Restructuring announcement	5
Sales (forecasting) announcement	4
Bond rating announcement	1
Management change announcement	3
Dividend announcement	1
Total confounding events	**35**

Table 2
Descriptive statistics of the product recall sample.

Panel A	**Recalls by product category**	**Number (Proportion)**
	Drugs/Cosmetics	26 (14%)
	Electric/Electronic	26 (14%)
	Food/Consumables	31 (17%)
	Rubber/Automotive Parts	75 (40%)
	Toys/Small Appliances	11 (6%)
	Miscellaneous	16 (9%)
	Total Events	**185**
Panel B	**Market size of the firms in the sample**	**Number (Proportion)**
	Over $5 Billion	110 (59%)
	Between $1 and $5 Billion	51 (28%)
	Between $500 Million and $1 Billion	10 (5%)
	Under $500 Million	14 (8%)
	Total Events	**185**
Panel C	**Severity of product recalls for the sample firms**	**Number (Proportion)**
	Class I	41 (22%)
	Class II	63 (34%)
	Class III	81 (44%)
	Total Events	**185**
Panel D	**Number of product recalls for the sample firms**	**Number**
	One Recall	70
	Two Recalls	18
	Three Recalls	4
	Four Recalls	1
	Five Recalls	2
	Six Recalls	2
	At Least Seven Recalls	4

Table 3
Operationalization and data sources of independent variables.

Variables	Operationalization	Data Source
Social media metrics		
Volume of online WOM	Total number of posts to the product recall of a firm within the event window	Alterian SM2 program
Valence of online WOM	Ratio of the total number of negative posts to the total number of positive posts plus negative posts about the product recall of a firm within the event window	Alterian SM2 program
Growth rate of online WOM	Rate of online WOM grows on average per day when a company announces a product recall, after considering the effects of compounding	Alterian SM2 program
Breadth of online WOM	Number of different social media platforms, from zero platforms to six platforms, that online WOM concerning the product recall appears	Alterian SM2 program
Company involvement	One dummy variable indicates that the company is involved in social media which is coded as "1" and "0" if otherwise.	Alterian SM2 program
Marketing variable		
Brand equity	One dummy variable indicates that the company appeared on the Fortune Most Admired Companies list as a strong brand which is coded as "1" and "0" if otherwise.	Fortune magazine
Control variables		
Recalled product units	Total number of recalled product units in an announcement	USASearch's product recall data set
Severity	Dummy variables indicate that the severity of a recall is Class I, II, or III	USASearch's product recall data set
Product category	Dummy variables indicate that the recall is in drugs/cosmetics, electrical/electronic, food/consumables, rubber/automotive parts, or toys/small appliances	USASearch's product recall data set
Number of product recalls	Total number of recall product recall announcements of a sample firm	USASearch's product recall data set
Firm size	Market value of equity	COMPUSTAT
Operating margins	Ratio of net income before depreciation to sales	COMPUSTAT
Financial leverage	Ratio of total liabilities to total assets	COMPUSTAT

Table 4
Abnormal returns of product recall announcement.

Event Day	Average Abnormal Return (%)	t-test	BMP test	Wilcoxon non-parametric test
-7	-.229	-1.49	-1.07	.62
-6	-.132	-1.08	-1.39	-.42
-5	.003	-.02	1.01	.78
-4	.104	.86	.58	1.50
-3	.143	.83	.26	.74
-2	-.030	-.24	-.89	-1.28
-1	-.188	-1.66*	-2.13**	-.97
0	-.237	-1.98**	-2.20**	-1.92*
1	-.026	-.18	.80	-.19
2	.023	.19	.16	1.01
3	.019	.15	-.37	.55
4	.314	1.79*	1.88*	2.49**
5	-.131	-1.12	-1.37	.77
6	-.201	-2.12**	-1.81*	.29
7	.151	.96	1.14	1.01

$^{*}p < .10$, $^{**}p < .05$

Table 5

Cumulative average abnormal return for windows surrounding the product recall announcement day.

Time Interval	Cumulative Average Abnormal Return (%)	T-statistic
[-7, 7]	-.425	-.77
[-7, -2]	-.147	-.46
[-5, 5]	-.013	-.03
[-5, -2]	.214	.77
[-2, 2]	-.459	-1.54
[-2, 0]	-.456	-2.23**
[-1, 0]	-.426	-2.62**
[0, 1]	-.264	-1.29
[-1, 1]	-.453	-1.92*
[1, 2]	-.003	-.01
[1, 5]	.199	.60
[1, 7]	.148	.40
[-1, 7]	-.278	-.67

* $p < .10$, ** $p < .05$

Table 6
Correlation matrix and descriptive statistics on CAR[-1, 1].

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Volume	1												
2. Valence	.206***	1											
3. Growth	-.052	.150**	1										
4. Breadth	.374***	.431***	.149**	1									
5. Company involvement	.382***	.201***	-.011	.328***	1								
6. Brand equity	.313***	.201***	.089	.436***	.368***	1							
7. Units^{+}	.012	.027	-.033	.057	.010	.016	1						
8. Severity	-.071	.066	.072	.003	-.027	-.054	-.035	1					
9. Category	-.122*	-.104	.138*	-.122*	-.096	.047	.146**	.142*	1				
10. Frequency	.121*	.175**	.086	.204***	.117	.079	-.071	.306***	.099	1			
11. Size^{+}	.415***	.169**	-.082	.387***	.423***	.084	-.022	.043	-.310***	.233***	1		
12. Operating margin	.085	-.004	-.038	.176**	.105	.134*	.001	-.069	-.119	.049	.239***	1	
13. Leverage	.090	.156**	.209***	.329***	.191***	.341***	.018	.008	.030	.036	.189***	.059	1
Mean	252.32	.57	.46	4.86	.18	.52	.32	2.22	3.35	4.42	36.03	.06	.56
SD	566.12	.38	.67	1.17	.39	.50	2.27	.78	1.41	4.97	52.32	.13	.19

* Significant two-tailed result at 10% level ($p < .1$).
** Significant two-tailed result at 5% level ($p < .05$).
*** Significant two-tailed result at 1% level ($p < .01$).
$^{+}$ Units (in millions); Size (in billions)

Table 7
Moderator analysis estimation results on CAR[-1, 1].

	Cumulative Abnormal Return (%)	Hypotheses
Volume of online WOM	-.004*	H_1(-): supported
	(.002)	
Valence of online WOM	-2.722***	H_2(-): supported
	(.854)	
Growth rate of online WOM	-1.486**	H_3(-): supported
	(.627)	
Breadth of online WOM	.703**	H_4(-): not supported
	(.337)	
Company involvement	-.888	H_5(+): not supported
	(.741)	
Brand Equity	-.039	
	(.800)	
Volume x Brand Equity	.004*	H_6(+): supported
	(.002)	
Valence x Brand Equity	3.944***	H_7(+): supported
	(1.490)	
Growth rate x Brand Equity	1.051	
	(.765)	
Breadth x Brand Equity	-1.289**	
	(.595)	
Recalled product units	-.084	
	(.106)	
Class I	-.167	
	(.709)	
Class II	-.061	
	(.558)	
Drugs/Cosmetics	-.330	
	(1.176)	
Electrical/Electronic	-.384	
	(1.051)	
Food/Consumables	.184	
	(1.059)	
Rubber/Automotive	.591	
	(1.026)	
Toys/Small Appliances	.241	
	(1.303)	
Number of product recalls	-.018	
	(.068)	
Firm size	.008	
	(.007)	
Operating margins	3.231	
	(1.998)	
Leverage	3.636**	
	(1.532)	
Intercept	-2.982**	
	(1.302)	
N	185	
R^2	.182	

Notes: Standard errors in parentheses.
* Significant two-tailed result at 10% level ($p < .1$).
** Significant two-tailed result at 5% level ($p < .05$).
*** Significant two-tailed result at 1% level ($p < .01$).

Table 8
Robustness checks.

	Focal Model	Extended Model	Subsample	Alternative Breadth
Volume of online WOM	-.004*	-.005*	-.003	.009
	(.002)	(.003)	(.003)	(.010)
Valence of online WOM	-2.722***	-2.662**	-2.806**	-2.195**
	(.854)	(1.138)	(1.277)	(.851)
Growth rate of online WOM	-1.486**	-2.049**	-1.735*	-1.274**
	(.627)	(.949)	(.890)	(.629)
Breadth of online WOM	.703**	.551	.873	-.011
	(.337)	(.384)	(.542)	(.010)
Company involvement	-.888	-.769	-2.268*	-.837
	(.741)	(.763)	(1.296)	(.750)
Brand Equity	-.039	.101	-.613	-.028
	(.800)	(.821)	(1.068)	(.813)
Volume x Brand Equity	.004*	.005*	.004	-.008
	(.002)	(.003)	(.003)	(.010)
Valence x Brand Equity	3.944***	3.862**	5.859***	2.768*
	(1.490)	(1.588)	(2.132)	(1.425)
Growth rate x Brand Equity	1.051	.984	.662	.836
	(.765)	(.806)	(1.050)	(.770)
Breadth x Brand Equity	-1.289**	-1.289**	-1.365	.010
	(.595)	(.640)	(.925)	(.010)
Recalled product units	-.084	-.084	-.052	-.080
	(.106)	(.108)	(.128)	(.108)
Class I	-.167	.312	-1.036	-.106
	(.709)	(.788)	(1.141)	(.719)
Class II	-.061	.066	-1.081	.132
	(.558)	(.583)	(.975)	(.567)
Drugs/Cosmetics	-.330	-.079	1.251	-.237
	(1.176)	(1.221)	(1.635)	(1.197)
Electrical/Electronic	-.384	-.410	.257	-.439
	(1.051)	(1.078)	(1.404)	(1.064)
Food/Consumables	.184	.051	1.084	-.007
	(1.059)	(1.098)	(1.487)	(1.075)
Rubber/Automotive	.591	.616	3.350*	.145
	(1.026)	(1.051)	(1.605)	(1.005)
Toys/Small Appliances	.241	.108	.637	.877
	(1.303)	(1.357)	(1.879)	(1.322)
Number of product recalls	-.018	.003	-.273	-.004
	(.068)	(.070)	(.216)	(.066)
Firm size	.008	.006	.010	.004
	(.007)	(.008)	(.011)	(.007)
Operating margins	3.231	3.279	3.355	4.058**
	(1.998)	(2.020)	(2.445)	(1.994)
Leverage	3.636**	4.022**	5.421**	3.616**
	(1.532)	(1.576)	(2.299)	(1.534)
Volume x Class I		.001		
		(.001)		
Valence x Class I		.0003		
		(.001)		

	Focal model	Extended Model	Subsample	Alternative Breadth
Growth rate x Class I		1.793 (1.854)		
Breadth x Class I		-1.320 (1.728)		
Volume x Class II		1.415 (1.748)		
Valence x Class II		.646 (.953)		
Growth rate x Class II		.047 (.702)		
Breadth x Class II		.585 (.578)		
Intercept	-2.982** (1.302)	-3.479** (1.390)	-3.503* (1.835)	-2.967** (1.320)
N	185	185	101	185
R^2	.182	.209	.288	.158

Notes: Standard errors in parentheses.
* Significant two-tailed result at 10% level ($p < .1$).
** Significant two-tailed result at 5% level ($p < .05$).
*** Significant two-tailed result at 1% level ($p < .01$).