Product Recalls, Resource Reallocation, and Contagion along the Supply Chain[+]

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This version: January 2013

Abstract

Product recall campaigns are material events for the recalling firms and their key stakeholders. In this paper, we study (i) the factors that explain the incidence of product recalls, (ii) the value implications of recalls for the recalling firms, their industry rivals, and key suppliers, and (iii) the operating consequences for the recalling firms and the actions taken by them in response to the recall. To address these issues, we compile a comprehensive dataset on recalls of a wide variety of products by publicly traded firms during the period 2006–2010 to test our hypotheses. Our final sample of 816 recall events includes consumer product, food, drug, medical devices, and automobile recalls. Our results indicate that the financial condition, competitive position, product and process innovation investments, coordination costs, incentives of workers and management, and the monitoring environment of the firm all have a significant impact on recall incidence. Further, recall events pose significant costs not only to the recalling firms, but also to their rival firms and key supplier firms. Our results show that instead of benefiting from the recalling firms' woes, industry rivals actually suffer adverse contagion effects, perhaps due to anticipated tighter regulations for the industry and diminished perceptions about the entire product category. In addition, the key suppliers of the recalling firms are also adversely affected. Controlling for the endogeneity of the product recall event we find that a larger investment in brand capital alleviates the negative impact of the recall announcement for recalling firms. A difference-in-differences approach shows that compared to control firms, recalling firms suffer sales decreases in the years immediately following the recall, and they increase advertising expenditures as a way to repair their tarnished brand image.

Keywords: Product recalls, contagion, supply chain, financial distress, product quality

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[+] This is a preliminary draft of the paper. Please do not cite without the permission of the authors.

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1. Introduction

A product recall campaign is an announcement by a firm to recall several units of its products from the marketplace due to the discovery of safety issues. Some of the more recent recalls include automobile recalls by Toyota Motor Corp due to malfunctioning accelerator pedals, Tylenol recalls by Johnson & Johnson due to foreign particles, laptop battery recalls by Sony Corporation due to fire hazard, malfunctioning defibrillator recalls by Boston Scientific, several food product recalls due to E. Coli and Salmonella infections such as ConAgra's recall of Peter Pan peanut butter and Banquet potpies, and numerous toy recalls due to unsafe lead content (e.g., recalls of Barbie accessories by Mattel and Bongo Band toys by Fisher-Price). Often, the recalled products are associated with harmful effects such as injury, sickness, or death. Recall events have received significant scrutiny from the media, politicians, and various U.S. agencies in charge of regulating product safety.[1]

The extant literature has shown that recalls are costly events for recalling firms and the costs of the recall far exceed the costs of replacing or repairing the defective products. These additional costs can include significant indirect penalties in the form of lost goodwill, tarnished brand image, and product liability lawsuits (e.g., Jarrell and Peltzman, 1985; and Barber and Darrough, 1996).[2] Most studies have either focused on an analysis of specific large recalls such as the 1982 Tylenol recall (e.g., Dowdell, Govindaraj, and Jain, 1992) or event studies of recalls that focus on specific products (e.g., automobile or drug recalls by Jarrell and Peltzman, 1985; Hoffer, Pruitt, and Reilly, 1988; and Barber and Darrough, 1996; food recalls by Thomsen and McKenzie, 2001; and drug withdrawals by Ahmed, Gardella, and Nanda, 2002). There is, however, a paucity of studies analyzing the firm- and industry-specific factors that explain the incidence of recalls, the effects of recalls on stakeholders such as suppliers, and the operating consequences and policy changes around recall. We offer insights on these issues in this paper.

[1] The U.S. agencies regulating safety for the different types of products are Consumer Product Safety Commission (*CPSC*), Food and Drug Administration (*FDA*), and National Highway Traffic Safety Administration (*NHTSA*).

[2] Specifically, Jarrell and Peltzman (1985), in their examination of automobile and drug recalls, find that the market penalized recalling firm shareholders for far more than the direct cost of the recall campaign. Barber and Darrough (1996) also find a significantly negative market reaction to automobile recall announcements. In the context of corporate criminal fraud, Karpoff and Lott (1993) find the loss in shareholder value is much larger than the penalties and/or settlement amounts, thereby highlighting the importance of reputational costs.

We use the incidence of a recall as a proxy for quality failure and empirically examine theories which suggest that certain firm-specific and industry-specific factors affect firms' incentives to invest in product quality and other related attributes that affect recall incidence. Some of these factors include the financial health of the firm, degree of industry competition, supply chain coordination costs, investments in process and product innovation, worker and managerial incentives, and the monitoring environment in firms. We also build upon extant studies in the literature which document that recall campaigns destroy value to recalling firms. We further explore whether key supplier firms who are dependent on the recalling firm for their sales are impacted by the announcement of a product recall, and go on to also analyze whether and when industry rivals benefit from the recalling firm's woes. In analyzing the effects on rivals (and suppliers) we carefully distinguish between *competitive* effects, where the recalling firms' losses translate into increased demand for the rivals' products, and *contagion* effects where a recall conveys bad news for the entire industry and to the upstream suppliers, such as impending increased regulatory attention, newer packaging, or other costly product standards for all firms in the industry.

Anecdotal evidence suggests that firms suffer significant real consequences and make material operational changes in response to the recall.[3] In one of the earlier papers on product recalls, Jarrell and Peltzman (1985) suggest that a future direction of research would be to identify specific costs of product recalls and state, *"The challenge for future research is to discover just what form - for example, reduced sales, increased quality costs, lost "political capital" these large, currently amorphous costs take."* We formally examine these issues by analyzing the impact of the recall on firms' sales, long-term and short-term expenditures such as production costs, capital expenditures, R&D investments, and advertising expenditures, and any other efforts to improve quality and rebuild brand image. In all the relevant

[3] One obvious adverse effect of recalls is a decline in sales. For example, following Boston Scientific's defibrillator recall Olmos (2010) estimates that, depending on shipment disruptions, Boston Scientific could lose $541 million in sales in 2010 alone, or 10 percent of its US market share. Firms may respond to this decline in sales through advertising, promotional activities, and operational changes. A case in point is Procter and Gamble which ran full-page advertisements in 59 daily newspapers outlining the steps they will take to address concerns of pet owners in the wake of the Iams pet food recall (see P&G press release of April 3, 2007, 8:08 am; http://news.pg.com/press-release/pg-corporate-announcements/iams-and-eukanuba-employees-publish-open-letter-today-reass).

analyses in the paper, we control for the endogeneity of the recall event by either conducting treatment effect estimations or propensity score matching as appropriate.

One reason for the dearth of extensive studies in the area of product recalls is perhaps the difficulty of obtaining reliable data on recalls. To conduct the analysis in this paper, we build a comprehensive database of product recalls covering the automobile, food and drug, medical devices, and general consumer product industries. We hand collect data on product recall campaigns announced by publicly traded firms during the 2006–2010 period. Specifically, we collect data on consumer product recalls from the *CPSC*, food, drug and medical device recalls from the *FDA*, and automobile recalls from the *NHTSA*. Our final sample comprises of 816 recall events over the sample period included in the regulating agencies' filings and with reliable announcement dates in the popular press. This database on product recalls is unique in the finance literature and offers rich variation in firm-specific and industry-specific factors that explain the occurrence of recalls.

Our examination of the valuation consequences across our large sample of 816 recalls indicates that these are material events in the life of the firm – they result in significant value destruction for the shareholders of the recalling firms. Specifically, we find that recalls in our sample are associated with an average wealth effect of –1.72% for the recalling firms over a (–5, +5) day window around the announcement date. In dollar terms this is roughly an average loss of $286 million to the firms in our sample. Furthermore, we show that key supplier firms who are dependent on the recalling firm for sales are negatively impacted by the announcement of a product recall. Specifically, they experience an average wealth effect of –1.23% over the same window. This suggests that recall events are associated with significant net vertical contagion effects. To the best of our knowledge, this paper is the first study to document that economic impairment from product recalls in a company ripples through the layers of its supply chain. We find that rival firms experience weakly negative announcement period wealth effects as well. Although rivals can benefit from some recalls and experience increased sales, the weak negative announcement period wealth effects indicate that contagion effects, possibly in the form of increased anticipated regulation and costly new standards for design, testing, manufacturing, and packaging of the products in the industry as a whole, outweigh these competitive effects.

Our analysis of the determinants of product recalls shows that the financial and competitive position of a firm along with product and process innovation investments, operating efficiency, and supplier coordination costs has a tangible effect on recall incidence. Consistent with Maksimovic and Titman (1991), who argue that firms with high financial leverage (or high probability of financial distress) have incentives to cut costs and reduce the quality of their products to avoid immediate bankruptcy, we document a positive relation between leverage (or equivalently, likelihood of financial distress and financial constraints) and the probability of a product recall. Our findings reinforce those in Matsa (2011b) and Phillips and Sertsios (2012) who also report a negative relation between quality and leverage/financial distress in the supermarket and airline industries, respectively.

Supply chain coordination problems may result in inefficient supply chain and production management, possibly resulting in lower product quality and a greater propensity to recall products (e.g., Kekre, Murthi, and Srinivasan, 1995; Shin, Collier, and Wilson, 2000; and Choi and Krause, 2006). Supportive of this view, we document that firms that source inputs from a fewer number of suppliers or are vertically integrated have a lower incidence of product recalls. Consistent with the idea that investments in quality and process innovation and superior managerial ability/more efficient operations reduce the occurrence of quality breakdowns, we find that the incidence of a recall is negatively related to R&D intensity and total factor productivity of the firm, respectively.

Additionally, in line with the arguments in Baldwin (1983) and Bronars and Deere (1993b) that firms with unionized employees tend to reduce their investment in physical capital and operate at an inefficient level, we document a positive relation between industry unionization and incidence of a product recall. Finally, we document a positive relation between market share (or industry Herfindahl index) and the incidence of a product recall. These results are consistent with the predictions in Chamberlin (1933) and Abbott (1955) that firms with greater market power are able to reduce product quality to maximize their profits. The results are also similar to the empirical findings in Matsa (2011a) and Mazzeo (2003) who find a negative relation between market power and product quality in the supermarket and airline industries, respectively.

Managerial incentives can also influence recall incidence. We expect managers to pursue long-term value-enhancing strategies such as optimal investments in quality and other measures to mitigate the incidence of quality failures when they have higher pay-performance sensitivity (*CEO delta*). On the other hand, we expect managers to implement riskier firm policies when they are given higher risk-taking incentives such as greater CEO pay-volatility sensitivity (*CEO vega*) and tournament incentives (*Compensation gap*) (e.g., Coles, Naveen, and Daniel, 2006; and Kini and Williams, 2012). We find that although *CEO delta* and *CEO vega* generally do not have a significant impact, higher tournament incentives, as measured by the pay gap between the CEO and the next layer of senior executives, have a detrimental effect on recall incidence. Finally, firms with higher institutional ownership, particularly by dedicated institutions, are likely to be subject to active monitoring of management (e.g., Bushee, 1998, 2001). Consistent with this notion, we find that firms with higher dedicated institutional ownership demonstrate a lower proclivity for product recalls.

We examine the determinants of the recalling firms' stock price reaction around the announcement of recalls, after controlling for the endogeneity of the recall event based on our recall incidence regressions. We find evidence consistent with the view that a firm's endowment of brand capital insulates it to some extent from the adverse consequences of the event. Analyzing the role of unionized workers, we document evidence consistent with the notion that recalling firms may be able to extract some concessions from unionized workers after the announcement of the recall. Further, we find weak evidence consistent with the view that the market believes that financially constrained firms have a more difficult time dealing with the consequences of a recall such as fixing the underlying problems that lead to the recall and avoiding predation by rivals.

We also find weak evidence to suggest that the market believes that recalling firms where senior executives have higher tournament incentives deal with a product recall more effectively once it occurs. We find that the market expects better aligned CEOs (higher *CEO delta*) to more effectively manage any fallout from the product recall better. However, the opposite is true if the recalling firm's CEO has greater risk taking incentives (higher *CEO vega*). We do not find a major role for institutional shareholders in dealing with a product recall. However, when we break up institutional ownership into its components based on the classification in Bushee (1998, 2001), we find some evidence that is consistent with the idea that transient institutional investors probably sell some or all of their holdings upon announcement of the product recall leading to a negative price pressure.

When we analyze rival and supplier firm reactions to the product recall, the results are consistent with the view that contagion effects dominate competitive effects in product recalls. Specifically, we find that rival firms' stock price reaction is positively related to the recalling firm's stock price reaction even after controlling for a variety of other factors. Thus, bad news for the recalling firm is viewed in the market as bad news for the rivals too, consistent with the expectation that there are significant spillover effects possibly in the form of increased regulatory scrutiny for the industry as a whole, reflecting impending costly changes to the processes within the industry. These spillover effects may also be in the form of additional packaging restrictions (e.g., Tylenol), or negative perception about the whole product category (e.g., SUVs and rollover risk), or fear of other costly restrictions that affect the industry as a whole (e.g., toy recalls due to unsafe lead content).

The result that there are negative spillover effects from the recall is further bolstered by our evidence on supplier reaction. We document a positive relation between the abnormal returns of the recalling firms and those of their key suppliers, even after controlling for a variety of firm- and supplier-specific characteristics. That is, the key supplier firms' losses are higher when the recalling firm's losses are higher. Overall, these results are consistent with the view that there are significant adverse spillover effects, both horizontal (industry-wide) and vertical (supplier), from product recalls. Furthermore, the key supplier firms' stock prices are more adversely affected if they have made more relationship-specific investments, thereby suggesting that it is more difficult for these suppliers to switch to the industry-rival firms of the recalling firm.

Finally, we study the impact of product recalls on the sales of the recalling firms and their subsequent corporate decisions. To account for the endogeneity of the recall event, we use a difference-in-differences approach using the propensity score matching as in Rosenbaum and Rubin (1983), and the Abadie and Imbens matching as in the Abadie and Imbens (2006), and Abadie, Drukker, Herr, and Imbens (2004) methodologies. Both types of methodologies control in different ways for the sample selection bias arising from the possible fact that the assignment of firms into the treatment (recalling firms) and control (non-recalling firms) groups is non-random.

Our results show that there are negative real consequences to firms that experience quality failures. The difference-in-differences analysis reveals that recalling firms experience a significant decline in sales relative to matched control firms in a one- and two-year window surrounding the recall announcement year. Our findings also show that recalling firms respond to the product crisis by increasing their advertising expenditures relative to control firms, indicating that they are attempting to repair their tarnished brand image by increasing investments in brand expenditures. The effects on the other policy variables that affect operations such as R&D and capital expenditures, inventory, and accounts receivables and payables are not consistently significant across the different matching procedures we use in our analyses.

Our paper makes the following contributions. First, to the best of our knowledge, no other paper has examined the firm- and industry-specific factors that have an impact on the incidence of recalls. Second, we provide a more complete picture of the impact of a product recall on various product market participants by examining the impact of the recall on the key suppliers of the recalling firm as well as on the industry rivals. Third, our examination of the cross-sectional determinants of the announcement period wealth effects to recalling firms, their key suppliers, and their industry-rivals yield new insights, and also provides more definitive conclusions about whether there are contagion effects associated with product recalls. Fourth, we examine the impact of product recalls on operating performance, and how firms change some of their policies in response to such an event.[4] Fifth, the findings from this study should be of interest to the U.S. product safety watchdogs such as the *CPSC*, *FDA*, and *NHTSA* in their regulation of product safety practices. Finally, our findings on factors that lead to recalls will help firms gain a better understanding of the trade-offs involved in determining an acceptable level for the probability of a recall.

The remainder of the paper proceeds as follows. Section 2 provides a discussion of the factors that we posit can affect the incidence of product recalls. Section 3 describes our data sources, sample selection criteria, and the salient characteristics of the sample. In Section 4, we present our univariate analysis followed by probit regressions explaining the incidence of recalls. In Section 5, we present our univariate and cross-sectional predictions and regression results pertaining to the announcement-period wealth effects of the recalling firms and those of their rivals and key suppliers. Section 6 analyzes the changes in sales, and key operating and firm-level liquidity variables around product recalls. We summarize our results and conclude the paper in Section 7.

2. Theoretical considerations for recall incidence: Hypotheses and variable description

In this section, we provide theoretical justifications for the selection of variables that are hypothesized to influence the incidence of product recalls. Detailed descriptions of all the variables used in this study are presented in the Appendix.

2.1. Financial leverage/distress and the propensity for a product recall

Maksimovic and Titman (1991) develop a model in which firms with high leverage (or high probability of financial distress) have incentives to cut costs and reduce the quality of its products to avoid immediate bankruptcy. Consistent with this argument, Matsa (2011b) finds that financial leverage undermines a firm's ability to provide superior quality in the supermarket industry. He uses the retailer's product shortfalls as a measure of product quality in the supermarket industry, and finds that higher leverage is associated with greater shortfalls. Phillips and Sertsios (2012) analyze the airline industry and

[4] Crafton, Hoffer, and Reilly (1981) study the sales impact of auto recalls in the month following the recall. We extend the analysis to include a wide set of operating and firm-level liquidity variables and recalls of all types of products, while at the same time controlling for the critical endogeneity issues involved in such analysis.

find that product quality decreases when the airline is in financial distress, which is consistent with the view that financial distress reduces incentives of the firm to invest in quality. In fact, in an *Associated Press* article, Choi and Murphy (2012) cite struggles with debt as a key reason why Hostess Brands Inc. was not able to invest heavily in innovation or marketing in recent years. We build upon this literature by using a product recall as a proxy for product quality. We argue that firms announce product recalls upon discovery of severe safety or quality issues and announcement of a recall campaign is indicative of quality failures. Based on these arguments, we expect a positive relation between the likelihood of a recall and measures of financial leverage/distress. We use measures of financial leverage based on book values (*Book leverage*) as well as market values (*Market leverage*) in our tests.

In addition, we use the Altman Z-score (*Altman Z*) measure developed by Altman (1968) as a measure of financial distress. Since firms with high values of *Altman Z* have a lower likelihood of financial distress, we expect a negative relation between *Altman Z* and the likelihood of recall. As an additional robustness test, we also use the *KZ index* developed by Kaplan and Zingales (1997) as a measure of financial constraints using the coefficients from Lamont, Polk, and Saá-Requejo (2001). A higher value for *KZ index* is indicative of a firm with greater financial constraints and, as such, we expect a positive relation between the likelihood of a product recall and the *KZ index*.

2.2. Coordination costs and the propensity for a product recall

2.2.1. Number of suppliers

Sourcing its inputs from many suppliers can make a firm less dependent on any one supplier and, thus, is a way to reduce input-related risk (e.g., Shin, Collier, and Wilson, 2000). In the process, the firm will incur higher coordination and transactions costs. These costs can include higher labor and order processing costs. Such firms will also need to expend significant resources to gather and analyze information about all the suppliers. In addition, there is a lower likelihood of long-term bilateral partnerships between the firm and all these suppliers, possibly leading to opportunistic behavior by some of them (e.g., Choi, and Krause, 2006). Further, multiple sourcing will result in the reduction of overall quality because there will be more variation in quality of inputs from suppliers due to different production processes employed (e.g., Treleven, 1987; Treleven and Schweikhart, 1988). Kekre, Murthi, and Srinivasan (1995) find that the use of a smaller number of suppliers is related to higher relative product quality. Thus, the potential for supply chain coordination problems are likely to be higher if the firm sources its supplies from a larger number of suppliers, which will ultimately lead to quality problems as evidenced by a higher proclivity for product recalls.

FASB 14 requires firms to report the names of customers that account for at least 10% their sales. This information is available on the Compustat database. We use it to generate the number of suppliers for all firms in our sample. While this database does not allow us to capture all the suppliers for a given customer firm, we believe that it is a reasonable proxy in the sense that if the true number of suppliers is higher, the number we compute is likely to be higher too, i.e., there is generally a monotonic relation between our proxy for the number of suppliers and the true number of suppliers.

2.2.2. Vertical relatedness between firm segments and the propensity for a product recall

A large theoretical literature argues that vertical integration reduces coordination costs associated with dealing with suppliers (e.g., Klein, Crawford, and Alchian, 1978). Ross, Westerfield, and Jaffe (2008, p. 817) state that, "The main purpose of vertical acquisitions is to make coordination of closely related operating activities easier." A vertically integrated firm is likely to source some of its inputs internally from segments in supplier industries and, thus, can potentially reduce coordination costs. In contrast, a non-integrated firm in the same industry will incur greater coordination costs in its dealings with supplier firms. These coordination problems may result in more inefficient supply chain and production management, possibly resulting in lower product quality and, as a result, a greater propensity to recall products. Thus, we expect vertically integrated firms to have a lower likelihood of a product recall. Using Compustat segment tapes, we measure the degree of vertical relatedness between the business segments of a firm. We create an indicator variable (*Vertical integration dummy*) that equals 1 if any two segments within the firm had a vertical supply relationship of 5% or more using the 2002 benchmark input-output tables published by the Bureau of Economic Analysis.

2.2.3. Capital-to-labor intensity

The more labor intensive the service or production process, the higher will be the probability that human error will occur. Furthermore, the coordination of activities among workers will become more difficult, thereby resulting in higher labor coordination costs. On the other hand, relatively greater use of capital will mean that the process is more likely to be automated, which will reduce the propensity for a breakdown in quality. We use the *Capital-to-labor intensity* as a measure of the relative use of capital and labor, with a higher value indicating relatively lower labor intensity, and predict that there is a higher likelihood of quality failures when this ratio is lower. We compute the *Capital-to-labor intensity* as the property, plant, and equipment per employee.[5]

2.3. Investment in quality/managerial ability and the propensity for a product recall

2.3.1. Long-term investments in quality and/or firm-specific assets

Firms that continually try to innovate and improve the quality of their current and future products by making long-term investments in quality are less likely to have product recalls.[6] R&D investments can be thought of as investments in innovations and/or long-term quality. In addition, Klein and Leffler (1981) suggest that firms are more likely to deliver high quality products in presence of significant firm-specific assets that are not salvageable outside the firm. To the extent that investments in R&D capture firm-specific assets (e.g., Allen and Phillips, 2000; and Kale and Shahrur, 2007), we expect to see a negative relation between R&D intensity and the occurrence of a product recall. As such, we predict that firms with higher R&D investments are less likely to have product recalls. The specific variable we use is R&D intensity which is defined as *R&D expenditures* over total assets.

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[5] The analysis in Sutton (2007) points to another possible linkage between capital-to-labor intensity and product quality. They argue that firms can signal their incentives to produce high quality products by engaging in production processes that involve high sunk costs. To the extent that firms with high capital-to-labor intensity have larger investments in sunk costs, their framework also suggests that firms with greater capital-to-labor intensity will be associated with higher product quality.

[6] Daughety and Reinganum (1995) derive a model in which they assume that R&D investments make products safer and conclude that the optimal level of R&D investments related to product safety will be determined by the firm's marginal cost of product safety risk.

2.3.2. Short-term investments in quality

A firm needs to make investments that are both short-term and long-term investments in quality to avoid events like product recalls. For example, the firm may want to source high quality raw material, employ skilled labor, have a sufficient number of supervisory managers, maintain its machinery on an ongoing basis, etc. all in an attempt to provide a quality product or service. We proxy for a firm's short-term investments in quality by *COGS-to-sales*, and predict a negative relation between it and the probability of a recall.[7]

2.3.3. Managerial ability and efficiency of operations

A large body of research examines whether managerial ability matters for firm performance and policies (e.g., Bertrand and Schoar, 2003; Gabaix and Landier, 2008; and Chang, Dasgupta, and Hilary, 2010 among others). This research finds that a significant variation in firm-level investment, financial, and organizational practices is explained by manager fixed-effects. We posit that firms that are better managed and have higher efficiency of operations are less likely to observe breakdowns in quality. We use total factor productivity as a measure of managerial ability. Higher total productivity indicates that the firm's managers have been more efficient in using factors of production like labor and capital in generating sales. We, therefore, predict that firms with higher total factor productivity will have a lower propensity to have quality failures.[8] We follow Faleye, Mehrotra, and Morck (2006) and calculate total factor productivity as the residual from a regression of the logarithm of the firms sales on the logarithm of the number of employees and the logarithm of property, plant, and equipment, where the regressions are run at the two-digit SIC industry level and year.

[7] Higher *COGS-to-sales* can also be symptomatic of managerial inefficiency and higher *R&D intensity* can capture agency problems within firms (Holmstrom and Costa, 1986; Meulbroek et al., 1990). If this were to be the case, then we expect that firms with higher *COGS-to-sales* or *R&D intensity* will have a greater propensity for product recalls.

[8] It is possible that managers can attain higher total factor productivity in the short-run by pushing their factors of production too hard in generating sales. In the longer-run, there will be relatively more breakdowns and greater stoppage times which may manifest themselves in a higher incidence of product quality failures.

2.4. Market power and the propensity for a product recall

Starting with Chamberlin (1933) and Abbott (1955), the theoretical literature has long argued that firms with greater market power have the ability to reduce product quality to maximize their profits. More recently, Mazzeo (2003) shows that quality is lower in concentrated airline markets. Matsa (2011a) also shows that quality, when measured as product availability and the overall shopping experience, decreases in concentrated supermarket industries. He also shows that quality improves when chain stores are faced with new competitive pressure, as in the form of arrival of Wal-Mart in the market. If higher quality products require higher levels of investment, costlier production processes, and greater effort on the part of the employees and managers, firms that operate in more competitive environments would face greater market pressure to incur these direct and indirect costs unlike those in less competitive environments. Similarly more dominant firms, such as those with a greater market share, may be able to get away longer with not incurring product quality-related direct and indirect costs.

Based on the above arguments, we expect a positive relation between industry concentration and the likelihood of a recall. In a similar vein, we expect a positive relation between a firm's market share and the likelihood of product recall. Industry concentration is measured as the sales-based Herfindahl index (*Herfindahl index*) of the recalling firm's industry using a three-digit SIC code and market share (*Market share*) is computed as the firm's sales over the total sales of its three-digit SIC industry.

2.5. Incentives and monitoring by institutions and the propensity for a product recall

2.5.1. Incentives of workers

For any firm, the product design and production processes are controlled by the firm's managers and other employees, whose effort, investment, and other resource allocation decisions are a function of the various incentives and disciplining mechanisms that control their compensation, perks, and job security. Employee unionization plays a significant role in this context. Rosen (1969) shows that the threat of unionization raises wages and benefits in firms and their rivals. In addition to higher wages, one of the other primary goals of labor unions is to negotiate greater job security for the union workers (e.g., Antell and Harris, 2004). In fact, Antell and Harris (2004) report that union workers often receive additional unemployment benefits from the employer that supplement any governmental benefits. Ruback and Zimmerman (1984) show that firms with unionized employees have lower profitability, and union formation is associated with significant losses to shareholders.[9] Bronars and Deere (1993a) show that the losses around union formation are a wealth transfer from shareholders to workers. Baldwin (1983) and Bronars and Deere (1993b) show that firms with unionized employees reduce their investment in physical capital and operate at an inefficient level. They go on to show that these firms have higher overall costs and lower profitability.

Given the above studies, we expect that unions are able to extract rents from the firm leading it to operate at higher costs and inefficient levels. Under this view, a higher unionization rate will increase the likelihood of a product recall. On the other hand if unionization affords a level of freedom to employees which improves decision-making and, thereby, product quality, we would expect a negative relation between unionization and the likelihood of a product recall. To capture labor incentives, we measure unionization (*Unionization*) as the percentage of employees in the industry that are unionized.

2.5.2. Monitoring by the market for corporate control

At the managerial level, Jensen (1986) argues that firms where the managers are not under any significant scrutiny, either because the market for corporate control in the industry is weak or because they have a diffuse shareholder base, have greater incentives to shirk and consume excessive perks. If lack of monitoring adversely affects labor and managerial effort and optimal resource allocation within the firm, we would expect the product quality of these firms to be poorer and hence these firms would have higher incidences of product recalls. We measure the strength of the market for corporate control using the *Merger intensity* variable, which is the fraction of takeover targets in the recalling industry in a given year relative to all takeover targets in the economy in that year. Higher merger intensity in the recalling industry is indicative of a more active corporate control market in that industry. We expect a negative relation between the merger intensity variable and the likelihood of product recalls.

[9] A case in point is the upcoming liquidation of Hostess Brands Inc. Choi and Murphy (2012) report that the high wages and health benefits costs associated with the firm's unionized workforce is partly to blame for its failure.

2.5.3. Monitoring by institutional investors

We measure shareholder monitoring using ownership of shares by certain types of institutional investors. To identify the type of institutional investors that are incentivized to monitor a firm, we use the classification system in Bushee (1998, 2001). Bushee (2001) classifies institutional investors into three categories. Transient institutional investors are those that have high portfolio turnover and highly diversified shareholdings. These investors' interest in a firm is confined to searching for short-term trading profits. Given their short investment horizon, they do not have an incentive to invest in any actions or information gathering that would further long-run value. In fact, Bushee (1998) finds that firms with a large transient institutional investor base tend to be significantly myopic in their investment behavior. Thus, if higher ownership by these institutions (*Transient ownership*) puts pressure on firms to act myopically, then they will not make the necessary short- and long-term investments in quality to boost short-term earnings, thereby resulting in a higher propensity for product recalls. Dedicated institutions are those characterized by large average investments in firms and extremely low turnover consistent with relationship investing and a commitment to providing long-term capital. Bushee (2001) states that dedicated institutions provide long-term stable ownership to firms because they are geared towards long-term income and capital appreciation. From a managerial and firm monitoring point of view, we expect dedicated investors to be active in monitoring the firm and so we use the percentage of the firm's shares owned by dedicated institutional investors (*Dedicated ownership*) as a proxy for active monitoring by institutions in the firm. We, therefore, expect a negative relation between the propensity for a quality breakdown and the level of dedicated institutional ownership. Quasi-indexers are institutions that either own the shares because the firm is part of an index that they are obligated to hold or act like indexers in their investment strategy such as exhibiting low turnover in their holdings. We have no prediction for the relation between quasi-indexer ownership (*Quasi-indexer ownership*) and the incidence of product recalls since they have some attributes of both transient institutional investors (unlikely to monitor) and dedicated institutional investors (have a relatively long horizon).

2.5.4. Incentives of top managers

We also examine whether managerial incentives have any bearing on the likelihood of product recalls. Specifically, we examine the impact of: (i) *CEO delta* (sensitivity of CEO wealth to stock price changes), (ii) *CEO vega* (sensitivity of CEO wealth to stock volatility), and (iii) *Compensation gap* (difference between CEO pay and the median VP pay) on the likelihood of a product recall. We expect that firms with higher *CEO Delta*, that is, higher pay for performance sensitivity, will have managerial incentives well-aligned with those of the shareholders (Jensen and Murphy, 1990; Hall and Liebman, 1998). Therefore, we expect these managers to pursue long-term value-enhancing strategies such as optimal investments in quality and other measures to mitigate the incidence of quality failures, thus resulting in a lower incidence of product recalls.

Coles, Daniel, and Naveen (2006) show that after adjusting for *CEO Delta*, CEOs with higher risk taking incentives (higher *CEO vega*) implement riskier firm policies both on the real and financial side. In a similar vein, Kini and Williams (2012) show that pay gap between the CEO and the next rung of senior executives (*Compensation gap*), which measures the tournament incentives offered to the VPs (i.e., high relative-reward of winning the "tournament" to become CEO), causes firms to implement riskier strategies.[10] Therefore, in the context of product recalls, both *CEO Vega* and *Compensation gap* will be related to riskier actions by firms, and thereby result in higher incidence of recalls. As such, we would expect these two variables to be positively related to the incidence of product recalls.

2.6. Firm Size

We use firm size as a control variable in all our models of the incidence of product recalls. Larger firms will produce and sell more products than smaller firms and, as such, the likelihood of quality failure will be higher for purely mechanical reasons. Larger firms are also likely to be more complex organizations with a larger number of external contracting relationships (e.g., Coles, Daniel, and Naveen,

[10] The distributive justice theory suggests that individuals alter their work effort to reflect their perceptions of pay equity. Consistent with this theory, Cowherd and Levine (1992) use business unit data and show that more equitable pay, as measured by a lower gap in pay between the lower-level and top-level managers, leads to superior product quality. Thus, a higher pay gap can result in more quality failures either because of greater risk taking or lower work effort.

2008; Booth and Deli, 1996). Thus, coordination costs arising from managing interactions between various parties within the firm as well as with external constituents are going to higher. As such, there is a higher probability of opportunistic behavior by various parties – suppliers, workers, managers, etc. – leading to a higher propensity for product quality failures. We use the logarithm of market value of equity (*Size*) as a proxy for firm size.

3. Data sources, sample selection, and salient characteristics

We collect data on product recall campaigns announced during the period January 2006 – December 2010 from three regulatory agencies in the United States that govern product quality and safety – the Food and Drug Administration (*FDA*), Consumer Product Safety Commission (*CPSC*), and National Highway Traffic Safety Administration (*NHTSA*). Specifically, we collect information on food, drug, and medical device recalls from the weekly enforcement reports published by the *FDA*. Each recall announcement by the *FDA* contains the name of the firm announcing the recall campaign, the product being recalled, the volume of recall, the reason for recall, and the recall date. We collect information on consumer product recalls from *CPSC*. The *CPSC* covers a diverse range of industries such as children's products, household appliances, heating and cooling equipment, home furnishings, toys, nursery products, workshop hardware and tools, yard equipment among others. Finally, we collect information on automobile recalls from the *NHTSA*. Specifically, we collect information on the manufacturer of the product, the product being recalled, the number of units recalled, the reason for recall, and the recall date.

Table 1 provides a summary of our final sample. It comprises of 816 recall events during the 2006–2010 period. Of these, 139 events are automobile recalls from *NHTSA*, 356 are food, drug, and medical devices recalls from *FDA*, and 321 are consumer product recalls from *CPSC*. The total number of recalls is roughly evenly spread across the years although there are some clusters within each category in certain years. Our sample consists of recalls spanning a wide range of industries – in fact, covering industries in more than 60 three-digit SIC codes. Table 2 shows the industry break-up of the sample using 2-digit SIC codes (33 different industry groups). Not surprisingly, Transportation equipment had the most recalls followed by Chemical and Allied products, Food and Kindred products, and Measuring and

Controlling instruments. Industries such as Lumber and Wood products, Stone, Clay, Glass, and Concrete products had nearly no recalls. Also, services industries such as Transportation Services, Business Services, and Health Services were associated with few recalls.

3.1. Is a product recall a material event?

To examine the market reaction to a recall announcement, we compute the announcement period stock returns over a variety of windows around the first announcement of the product recall. The recall date as reported by the *FDA* and *CPSC* is the date the firm first announces the recall campaign, usually through a press release or correspondence through email or letter. The *NHTSA*, however, reports three different dates related to the campaign: the date a safety issue was reported to *NHTSA* (*report received date*), the date of record creation, and the date of owner notification. The date of owner notification is typically several weeks or months after the *report received date*.

To identify the event date to be used in our event study analyses, we search for news articles related to the recall on the Factiva database for each recall identified from the above three sources. In particular, we attempt to find the date of the first news article on Factiva that reports the recall event. For matching our recall events to Factiva, we mainly use the name of the recalling firm, the product being recalled, the reason for the recall, and quantity of recall. We observe that the recall dates reported on the *CPSC* and *FDA* websites very closely match the date of the first news article in the media. Typically, the date of the first news article as reported in the media fell on the same day as the recall date indicated by the *FDA* and *CPSC*. Therefore, we use the recall dates collected from *CPSC* and *FDA* as the event date in our event study analyses. For the *NHTSA* sample, we find that the date of the first news article on Factiva was close to the *report received date* but was well before the date of owner notification. In fact, in the vast majority of the cases we find that the date the first news article is the same as the *report received date*. Hence, for the *NHTSA* sample we use the *report received date* as the event date. Recall events that were not reported on any of the publications or information sources covered by Factiva are excluded from our analyses. Similarly, recall events that were announced by non-public firms are also not considered in our analyses.

We compute the market model announcement period abnormal returns (CARs) for a variety of windows including (–2, +2), (–5, +5), (–10, +10), (–10, +2), and (–20, +20) around day 0, the announcement date of the product recall. We use the CRSP value-weighted market index for the market portfolio. Our choices of event windows are slightly wider than those seen in event studies of other corporate events but are consistent with those used in Jarrell and Peltzman (1985) and Hoffer, Pruitt, and Reilly (1988). The reason for the slightly wider windows is some recalls are preceded by a few days by news reports of accidents and adverse events related to the product use and, consequently, the impending recall may have been effectively "leaked" to the market. So, we study windows ranging from just two days prior to the event and all the way up to twenty days prior to the event. We also report the percentage of positive abnormal returns in each of the windows and the abnormal dollar impact of the event on the firms' stock. The dollar losses (or gains) are computed as the product of the relevant CAR and the market capitalization of the firm's equity prior to the start of the event window. The announcement period wealth effects are reported in Table 3. For the overall sample of all recalls, the (–5, +5) event window has an announcement period return of –1.72%, which is statistically significant at the 1% level. The results also show that, for this window, nearly two-thirds of all firms exhibit negative abnormal returns to the announcement of product recalls.

Product recalls result in over $300 million average abnormal decrease in market capitalization for the recalling firms. The average dollar wealth effect is even more negative (over $520 million) if we focus on the larger, (–10, +10) window. Since there are many small scale recalls, we also compute the abnormal dollar change for the median firm. That figure is smaller, yet significant, at over –$37 million. These results are consistent across the different windows in the overall sample of recalls, and clearly demonstrate that product recalls are very significant events in the life of a company with substantial negative wealth effects for the shareholders of recalling firms.

We also decompose the sample into its three main constituent groups – the *FDA*, *CPSC*, and *NHTSA* recalls. The *CPSC* sample shows the most negative announcement period abnormal returns, resulting in –2.42% and –3.22% abnormal returns in the (–5, +5) and (–10, +10) windows, respectively.

The *FDA* sample shows negative abnormal returns of –1.57% and –1.71% in the (–5, + 5) and (–10, +10) windows, respectively. The figures are all statistically significant at the 1% level of significance. Since the *FDA* recall sample has larger firms compared to the *CPSC* sample firms, the dollar wealth effects are quite large in the *FDA* sample (–$320 million) despite the smaller magnitude in percentage returns. The *NHTSA* sample also shows a similar pattern. The abnormal returns are, however, less negative and are statistically significant at the 1% level only in the longer event windows such as the (–10, +10) window. The dollar wealth effects are also smaller compared to the other two subsamples.

3.2. Salient characteristics of product recall and control firms

Table 4 presents univariate comparisons between recall firms and control firms. The sample of control firms comprises of all firms that are from the same three-digit SIC industries as the sample (recalling) firms, but have not had a product recall in any of the years in our sample period. With the exception of managerial incentives and institutional monitoring variables, the descriptive statistics for all the other variables for the recall and control firms are provided in Panel A. We derive managerial incentives using compensation data available of ExecuComp and, as such, the sample size for recall and control firms drops significantly. The descriptive statistics for managerial incentives and institutional ownership variables for recall and control firms are provided separately in Panel B.

Consistent with the view that recalling firms have higher leverage, are more financially constrained, and have a higher likelihood of financial distress, we find that they have markedly higher leverage (both book and market measures), a lower *Altman Z* score, and a higher *KZ index*. All these univariate differences are statistically significant.

The results are also consistent with the notion that recalling firms have more supply chain coordination costs in that they have significantly more suppliers from whom they source their inputs than control firms. We find that *Capital-to-labor intensity* is significantly higher for recalling firms. This result is inconsistent with our expectation that relatively more automated production processes and/or lower labor coordination costs as proxied by higher capital-to-labor intensity will result in fewer mistakes in the production process and, hence, fewer recalls. The recalling firms have significantly lower cost of goods sold as a fraction of sales, R&D intensity, and total factor productivity. The lower R&D intensity and cost of goods sold among the recalling firms is consistent with the view that recalling firms spend less on long-term and short-term investments to improve product quality. The lower total factor productivity of recalling firms is consistent with the notion that managers of recalling firms are less efficient than those of non-recalling firms.

Both *Herfindahl index* and *Market share* are significantly higher for recalling firms than for non-recalling firms. These results are consistent with the view that recalling firms have fewer market pressures in that they are either among the more dominant firms in their industries or they operate in less competitive (highly concentrated or oligopolistic) industries. The market share difference may also reflect the fact that the recalling firm is possibly larger and produces more units, and hence is more prone to recalls due to production process and other errors that are mainly a result of high volume of activity.

Finally, we find that recalling firms are in industries with significantly lower merger intensity (*Merger intensity*) than non-recalling firms suggesting less pressure on recalling firms and their managers through the market for corporate control. Recalling firms have lower dedicated institutional ownership (*Dedicated ownership*) than non-recalling firms. This is consistent with the view that monitoring by dedicated institutions can affect quality and mitigate the incidence of product recalls. Contrary to our expectations, we find that the ownership by transient institutional investors (*Transient ownership*) is also significantly lower for recalling firms.

We find that *CEO delta*, *CEO vega*, and *Compensation gap* are all significantly higher for recalling firms than for non-recalling firms. The *CEO vega* (*Compensation gap*) result is consistent with the notion that the CEOs (senior executives) in recalling firms have greater risk taking incentives. The higher *CEO delta* for recalling firms is, however, not consistent with the notion that higher pay-for-performance sensitivity aligns managerial interests with those of the shareholders and causes managers to pursue long-term value-enhancing strategies such as optimal investments in quality to mitigate the incidence of recalls. In the next section, we analyze probit regressions to examine the incremental impact of each of the above variables in affecting recalls in a multivariate setting.

4. Empirical analysis of recall incidence

4.1. Full sample of recall and control firms

In this section, we empirically investigate our hypotheses about the firm- and industry-characteristics that can impact the likelihood of recall incidence in a cross-sectional regression setting using Probit regression models. Specifically, our main specification is expressed as:

$$\begin{aligned} RecallDum_{i,t+1} = {} & \beta_0 + \beta_1 Financial\ constraint_{i,t} + \beta_2 Number\ of\ suppliers_{i,t} \\ & + \beta_3 Vertical\ integration\ dummy_{i,t} + \beta_4 Capital-to-labor\ intensity_{i,t} \\ & + \beta_5 COGS-to-Sales_{i,t} + \beta_6 R\&D\ intensity_{i,t} + \beta_7 Total\ factor\ productivity_{i,t} \\ & + \beta_8 Market\ power_{i(k),t} + \beta_9 Unionization_{k,t} + \beta_{10} Merger\ intensity_{k,t} + \beta_{11} Size_{i,t} \\ & + Year\ and/or\ industry\ dummies_{i,t} + \varepsilon_{i,t+1} \qquad (1) \end{aligned}$$

In the above specification, the dependent variable, *RecallDum* is a dummy variable that takes the value 1 if a recall incidence takes place for firm *i* in year *t+1*. All independent variables are lagged by one year. We use four alternative measures of the financial condition of the firm in the estimated regressions – *Book leverage*, *Market leverage*, *Altman Z*, and *KZ index*. In addition, we use two different measures of market power – *Market share* and *Herfindahl index*.

The results are reported in Table 5. We include year dummies in the regressions reported in Panel A, while we include both year- and three-digit SIC industry dummies in the regressions reported in Panel B. The table reports marginal effects and their respective *p*-values in parentheses. These *p*-values are based on heteroskedasticity robust standard errors and are clustered by firm. The results reported in Panel A indicate that if the firm has higher leverage, or faces tighter financial constraints, or has a higher risk of financial distress, then the likelihood of a product recall will be larger. Specifically, we find that there is a significantly positive relation between the probability of a product recall and leverage – both book and market leverage – at the 1% level of significance in all the estimated regressions. Further, we find that the relation between the likelihood of a recall and *Altman Z* is negative and significant also at the 1% level in the estimated regressions. Note that a higher value of *Altman Z* signifies a lower risk of financial distress. In addition, we find that the relation between the probability of a product recall and the *KZ index* is positive and significant at least at the 5% level. These results are consistent with the hypothesis that firms with higher leverage/tighter financial constraints/greater risk of financial distress have incentives to cut costs and reduce the quality of its products to avoid financial distress, thereby increasing their propensity to recall products.

We find the incidence of recalls is higher if *Number of suppliers* is greater. This marginal effect is significant at least at the 1% level. This result is consistent with the idea that it is more difficult and costly to coordinate with suppliers and monitor the quality of all its inputs if the firm sources them from a larger number of suppliers, thereby resulting in poorer quality products. In addition, we document a significantly negative relation at the 1% level between the probability of a product recall and *Vertical integration dummy*, suggesting that the vertically integrated firms have been able to successfully reduce coordination costs across different layers in the production process by bringing some of these layers under one umbrella resulting in better quality products. Further, we find a significantly negative relation – at least at the 1% level – between the probability of a product recall and the *Capital-to-labor ratio*, thereby indicating that there is a higher likelihood of quality failures when there is a relatively greater use of labor in the production process. This negative relation is also consistent with theory arguing that firms with higher sunk costs in property, plant, and equipment have greater incentives to produce quality products.

We find that the relation between the likelihood of a product recall and *COGS-to-sales* is significant and negative at the 1% level in the estimated regressions. Similarly, we find that the relation between the probability of a product recall and *R&D intensity* is negative in all the estimated regressions and significant at least at the 10% level in 7 out of the 8 estimated regressions. Thus, if *COGS-to-sales* can be construed as a proxy for short-term investments in quality and *R&D intensity* as a proxy for innovation and/or long-term investments in quality, our results are consistent with the notion that firms that make such investments are less likely to experience quality failures as captured in a lower propensity for product recalls. These results are, however, inconsistent with the idea that higher *COGS-to-sales* is symptomatic of managerial inefficiency and higher *R&D intensity* captures agency problems within firms. In addition, we find that there is a significant and negative relation at the 1% level in all the estimated regressions between the propensity to have a product recall and *Total factor productivity*. If higher total productivity implies more efficient use of factors of production – labor and capital – in generating sales and, thus, can be thought of as a proxy for managerial ability, our results are consistent with the hypothesis that we are less likely to observe product recalls for firms with more efficient managers. This result is, however, inconsistent with the notion that higher total factor productivity is attained by managers pushing their factors of production too hard in generating sales because that would have shown up in higher incidence of product quality failures.

We use *Market share* and *Herfindahl* index interchangeably as proxies for the market power of the firm in their product markets. *Market share* is a measure of the power of a firm within an industry; while *Herfindahl index* is a measure of the power of firms within an industry vis-à-vis their customer firms. We find that the relation between the probability of a product recall with both measures of market power is significantly positive at the 1% level. These results are consistent with the hypothesis that firms that see themselves as relatively immune to product market discipline because of market power are more likely to have quality failures as evidenced by a greater propensity for product recalls.

We find that degree of unionization in the industry increases the propensity for a firm to have a product recall (significant at the 1% level). This result is consistent with the notion that unions offer protection to workers and, as such, their incentives to enhance quality are diminished because their job risk is lower. Alternatively, since unions negotiate employment terms including wages and benefits, the fixed claims against the firm increase, and they may have to make some compromises on product quality to protect their cost structure. Further, we find a significant negative relation at least at the 10% level between the probability of a product recall and *Merger intensity*. This result is consistent with the hypothesis that managers of firms facing a greater threat of discipline from the market for corporate control are more likely to put in the requisite effort to manage the firm efficiently. A manifestation of this effort is to ensure that their firms will not suffer quality failures because these failures by themselves may trigger takeover bids for their firms. Finally, we find that larger firms are more likely to have product recalls. This result can be attributable to the fact that larger firms are likely to be more complex organizations and will produce/sell in higher volumes and, thus, either due to greater coordination problems within these firms or for purely mechanical reasons, there will be a greater chance that some of their output will have defects.

To more intuitively assess the economic significance of our results, we examine the change in implied probability of a product recall if the value of the independent variable in question changes from its 10th to 90th percentile value, while all the other independent variables take on their median values. For a dummy independent variable, we assess the change in implied probability as its value changes from zero to one. The changes in implied probability have to be evaluated relative to the unconditional probability of 6.73% (763 recall observations from a total of 11,332 total observations). For purposes of brevity, we provide these numbers only for Model 1 of Table 5.

We find that as *Book leverage* changes from its 10th to 90th percentile value, the implied probability of a product recall goes up by 1.28%. The changes in implied probability of a product recall are 0.28% and -0.74% as the values of *Number of suppliers* and *Capital-to-labor intensity* increase from their 10th to 90th percentile values, respectively. We find that the implied probability is 1.20% lower for vertically integrated firms than for firms that are not vertically integrated. In addition, as *COGS-to-sales*, *R&D intensity*, and *Total factor productivity* increase from their 10th to 90th percentile values, the implied probability of a product recall declines by 1.98%, 1.30%, and 1.83%, respectively. We find that the change in implied probability of a product recall is 0.49% (1.29%) as *Market share* (*Herfindahl index*) increases from its 10th to 90th percentile value.[11] As *Unionization* (*Merger intensity*) increases from its 10th to 90th percentile value, the implied probability of a product recall increases (decreases) by 4.14% (1.21%). Finally, as *Size* changes from its 10th to 90th percentile value, the increase in the implied probability of a product recall is 11.69%. Given that the unconditional probability of a product recall is 6.73%, it appears that these variables have an economically meaningful impact on the incidence of product recalls.

As mentioned earlier, in the Probit regressions reported in Panel B, we additionally control for industry dummies. The results indicate that the signs and significance of firm level variables are largely

[11] We compute the economic significance for *Herfindahl index* based on Model 3.

similar to those in Panel A. With industry dummies, the estimation of industry level variables relies on their time-series variation. With the exception of *Merger intensity*, our conclusions regarding all other industry level variables are the same as described earlier. We now find that *Merger intensity* is significantly positively related to the probability of a product recall. A possible explanation for this finding is that if there is an unusually high amount of merger activity in an industry in a given year, it may be a reflection of some industry wide problem that is subsequently reflected at least partly in higher recalls.

4.2. ExecuComp sample of recall and control firms

In what follows, in addition to the firm- and industry-characteristics we examine in Table 5, we also test to see whether CEO and top executive incentives as well as different types of institutional ownership have an impact on firms' propensity to recall their products. As noted in the previous section, since we need compensation-related data to examine the impact of CEO and top executive incentives, we restrict our analysis in this section to a sample of product recall and control firms that have data on the ExecuComp database. The results from this analysis are reported in Table 6.

We find the relation between the probability of a product recall and *Compensation gap* is significantly positive at the 1% level. This result suggests that a greater pay gap between the CEO and the next rung of executives generates incentives for these executives to take on higher risk and one of the outcomes of this risk taking behavior is a higher proclivity for quality failure. Further, we find that the sign on *CEO delta* is negative but the marginal effect is insignificant in all the estimated regressions. In addition, we find that the sign on *CEO vega* is positive in all four estimated regressions but the marginal effect is significant at the 10% level only in 1 out of the 4 estimated regressions (Column (4)). In 2 out of the remaining 3 estimated regressions, it is close to significance at the 10% level. Thus, we find weak evidence indicating that there is a higher likelihood of product recalls if CEO risk-taking incentives – as indicated by *CEO vega* – are greater.

Finally, amongst the three types of institutional ownership, we find that only *Dedicated ownership* has a significant impact of the likelihood of a product recall. Specifically, we find that the relation between the probability of a product recall and *Dedicated ownership* is significantly negative at the 1% level in all 4 estimated regressions. This result is consistent with our hypothesis that more ownership by dedicated institutional investors results in greater monitoring of managerial actions, resulting in a lower propensity to have product quality failures. The results on the firm- and industry-related variables employed in Table 5 are somewhat weaker in this smaller sample, but our general conclusions regarding these variables remain unchanged.

We assess the economic significance, based on Model 1 in Table 6, of the additional incentive and institutional ownership variables that we added in this table. Note that since we restrict the sample of firms to those with data available on ExecuComp, they will tend to be larger in comparison to those employed in the regressions in Table 5. Thus, it should come as no surprise that the unconditional probability of a product recall is higher here (17.52% versus 6.73%). We find that the implied probability of a product recall is higher by 7.68% (6.81%) as the value of *Compensation gap* (*CEO vega*) increases from its 10^{th} to 90^{th} percentile value. Finally, as *Dedicated ownership* increases from its 10^{th} to 90^{th} percentile value, the implied probability of a product recall decreases by -6.33%. Clearly, these variables also have a significant and economically meaningful impact on the probability of a product recall.

5. Wealth effects of recalling, rival, and supplier firms around recall announcements

5.1. Univariate wealth effects of rival and supplier firms

In Table 7, we analyze the stock price reaction of rivals and key suppliers of firms that announce recalls. We expect two effects to be at play. The first is the competitive effect where if product recalls have a negative effect on customer perception about the company's product quality, this may shift demand to the firm's rivals. This should result in positive announcement period abnormal returns for the rivals. In the context of bankruptcies that occur due to idiosyncratic reasons (i.e., not industry-wide or economy-wide reasons), Aharony and Swary (1983) show evidence of such competitive effects among industry rivals.

On the other hand, if the product recall conveys information such as increased regulatory attention, newer packaging, or other product standards for all firms in the industry, then we should observe a negative stock price reaction for the rivals. For instance, following the Tylenol recall in 1982, costly new packaging regulations were introduced for the entire industry. Tylenol lost $2.31 billion in value over a 9-day day period following the incident, but the industry as a whole also lost a very significant $8.68 billion – a loss of $310 million for each firm. Similarly, Crafton, Hoffer, and Reilly (1981) and Reilly and Hoffer (1983) show in their study of automobile recalls that industry rivals that produce similar line cars suffered sales declines following severe automobile recalls. If both competitive and contagion effects are in play, then the effect on rival firms will depend on which effect of these two effects dominates.[12]

The results in Panel A of Table 7 show that the announcement-period abnormal returns for the rivals are generally negative but very close to zero. Rivals are all firms on Compustat that are in the same three-digit SIC code as the recalling firm during the recall year, but have not announced a recall of their own within a 20-day period on either side of the recall announcement. For each firm we then form an equally-weighted portfolio of the firm's rivals to compute the announcement period abnormal returns over the various event windows using the market model. We use the CRSP value-weighted market portfolio as the proxy for market index. In the full sample of rivals (*FDA*, *CPSC*, and *NHTSA* together), the abnormal returns in the (–5, +5) window is a statistically insignificant –0.15% (t-value = –1.62), while the abnormal returns in the (–10, +10) and (–20, +20) windows are –0.35% and –0.63%, respectively, which are both statistically significant at the 5% level. The abnormal returns in the other windows tend to be negative but are generally statistically insignificant. We observe a pattern of mostly negative but statistically insignificant abnormal returns when we analyze the rivals of recalling firms in the three categories separately. Overall, these results are consistent with the view that both the competitive and contagion effects may be at play in the recalling industries, but the contagion effect dominates slightly and renders a product recall a slightly negative event for all firms in the industry.[13]

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[12] Lang and Stulz (1992) examine contagion and competitive effects in the context of bankruptcy announcements.
[13] In unreported results, we follow Hertzel, Li, Officer, and Rodgers (2008) and examine the wealth effects of the recall event on the industry-rival firms split by the median *Herfindahl index* of the recalling firm's industry. We

Panel B of Table 7 analyses the abnormal returns to the key suppliers of the recalling firms. Key suppliers of each firm are identified from the Compustat database based on the FASB No. 14 requirement that firms report their customers that account for at least 10% of sales. For each recalling firm, we then form an equally-weighted portfolio of the firm's suppliers to compute the announcement-period abnormal returns over the various event windows again using the market model. We expect the product recall to have a significant negative impact on the firm's key suppliers. Although suppliers who provide relatively non-specialized inputs may be able to easily re-tool and supply to the recalling firm's rivals, given the negative impact of the recall on the whole industry, we expect this possibility to not significantly offset the first-order negative impact of the recall on the suppliers.

Our results are strongly consistent with this view that product recalls do have a significant negative impact on the demand for the products of the upstream firms (key suppliers). Specifically, in the overall sample of suppliers of all recalling firms, we observe negative abnormal returns in all the event windows. For example, the announcement period abnormal returns are –1.23% and –1.85% in the (–5, +5) and (–10, +10) windows, respectively. Both are statistically significant at the 1% level. Similar results are found when we analyze the suppliers in the three subsamples, *FDA*, *CPSC* and *NHTSA*, separately. The percentage of suppliers with negative abnormal returns is also statistically significantly different from 50% in all the windows and at least at the 5% level of significance. These results indicate that suppliers suffer the direct adverse consequences of a product recall by a downstream firm.[14] These results are similar in spirit to those documented in Hertzel, Li, Officer, and Rodgers (2008) who find vertical contagion effects in corporate bankruptcy events.

5.2. Determinants of wealth effects of product recall firms

In this section, we examine the determinants of the announcement-period wealth effects to recalling firms in a multivariate setting. We propose that the brand capital of the firm (*Brand capital*) is

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generally find insignificant differences between the wealth effects of industry-rival firms in low- and high-concentration industries. We should have observed a differential effect under the competitive effects hypothesis.

[14] In unreported results, we also examine the wealth effects of the recall event on the key suppliers of the industry-rival firms (but who are not the key suppliers of the recalling firm) and find insignificant abnormal returns to them.

likely to impact the stock market reaction to a product recall.[15] *Brand capital* can serve as a barrier to entry (e.g., Waldman and Jensen, 2007, pp. 455-456). Therefore, in the face of a product recall, it can somewhat insulate the firm from the negative fallout from this adverse event. On the other hand, a firm that has invested more in *Brand capital* has built reputation capital and, thus, has more to lose from any event that signifies that its products are low quality. Thus, the hypothesized relation between announcement-period abnormal returns and *Brand capital* is ambiguous.

We had earlier argued that increased *Unionization* will make the probability of a product recall higher. However, conditional on a recall, the firm can use this event as a basis to extract rents from union workers. The question of extracting rents from non-union workers will not arise because their surplus wages/benefits are likely to be zero to begin with. Under this scenario, we predict a positive relation between the stock price reaction to product recalls and *Unionization*. We can obtain the opposite prediction here too if workers in unionized industries are more likely to resist making the requisite changes and/or are likely to be slower to adapt to ensure that the firm does not face similar breakdowns in quality in the future too.

Further, if the recalling firm is more financially constrained, then it is less likely to have the financial wherewithal to make the necessary changes to fix the problems related to procurement, design, manufacturing, etc. that lead to the product recall. Further, predation by rival firms will be more likely if the recalling firm is financially constrained (e.g., Bolton and Scharfstein, 1990; Maksimovic, 1995). We, therefore, predict a negative relation between the announcement-period abnormal stock return and the *KZ index* of the recalling firm.

A higher *Compensation gap* will give incentives to senior executives in firms to take on more risk (e.g., Kini and Williams, 2012). It will, however, also motivate them to work harder (e.g., Kale, Reis, and Venkateswaran, 2009). Thus, while a higher *Compensation gap* may result in senior executives taking more risks thereby resulting in greater incidence of recalls, they have tournament incentives to work

[15] *Brand capital* is the logarithm of the investment in brand and calculated as per the methodology in Lin, Belo, and Vitorino (2012). Please see the Appendix for details.

harder when the firm faces any type of adversity like a product recall. We, therefore, predict a positive relation between announcement-period abnormal returns and *Compensation gap*. A higher *CEO delta* implies that the CEO's incentives are more aligned with shareholders, while a higher *CEO vega* implies that the CEO has greater incentives to take on more risk. A more aligned CEO will work harder to ensure that the recall event will not occur again, while a CEO with great risk taking incentives is more likely to take on riskier projects where the chances of quality failures are going to be higher. Thus, we expect a positive (negative) relation between announcement-period abnormal returns and *CEO delta* (*CEO vega*).

Institutional ownership can also have an effect on the stock price reaction to announcements of product recalls. Transient institutional owners are the most likely to disinvest at the first sign of trouble and their unloading of the stock can potentially have a negative impact on the stock price if the demand curve for the stock is downward sloping. Since dedicated institutional owners have a longer term perspective, they will monitor the firm intensively after the product recall to make sure that quality breakdowns do not occur in the future. We, therefore, expect a negative (positive) relation between the announcement period stock price reaction and *Transient ownership* (*Dedicated ownership*). As before, we have no specific predictions for the relation between ownership by quasi-indexers and recall firm wealth effects. Finally, we include *Initial recall dummy* and *Size* as control variables in the estimated regressions.

Since we can only estimate the relation between the stock price reaction to product recalls and the above explanatory variables for firms that have a product recall announcement, we use the Heckman selection model regression approach. We report these results in Table 8. In Models 1 and 3, the announcement period abnormal returns are measured over the (–5, +5) window, while in Models 2 and 4, the announcement period abnormal returns are measured over the (–10, +10) window. In Models 1 and 2, we do not include the management incentive and institutional ownership variables, whereas in Models 3 and 4 we include them. Accordingly, in Models 1 and 2, we estimate the first-stage regression models using the determinants of the incidence of product recalls in Table 5, whereas in Models 3 and 4, we use the determinants of the incidence of recalls in Table 6. In all four models, we use weighted least squares regressions to explain determinants of wealth effects.

The coefficient associated with *Brand capital* is positive in all four regressions and is significant at least at the 10% level in 3 out of 4 estimated regressions. Thus, *Brand capital* does appear to insulate the recalling firm from some of the adverse consequences of the recall event. We also document a positive relation between abnormal returns and *Unionization*. The coefficients associated with *Unionization* are significantly positive at least at the 5% level in 3 out of 4 estimated regressions and is just outside conventional value for significance (p-value = 0.128) in the remaining regression. This positive relation is consistent with the notion that the firm can extract some concessions from unionized workers after the announcement of the recall. The coefficient on the *KZ index* is negative in all 4 estimated regressions, but is statistically significant at least at the 10% level only in 2 of the 4 estimated regressions. Thus, we find some evidence consistent with the notion that financially constrained firms are expected to have a more difficult time in dealing with the consequences of a recall, for example, like fixing the underlying problem that lead to the recall or avoiding predation by its rivals. The coefficient on *Compensation gap* is significantly positive at the 10% level in 1 out of 2 estimated regressions, thereby providing some weak evidence to suggest that the market expects firms in which senior executives have higher tournament incentives to deal more effectively with product recalls. *CEO delta* (*CEO vega*) is significantly positively (negatively) at least at the 5% (10%) level in both estimated regressions. These results indicate that the market expects a better aligned CEO to more effectively manage any fallout from the product recall better. However, the opposite is true if the recalling firm's CEO has greater risk taking incentives. The coefficient on *Transient ownership* is significantly negative at least at the 10% level in both estimated regressions, thereby suggesting that these investors probably sell some or all of their holdings upon announcement of the recall leading to negative price pressure. We do not document a significant relation between wealth effects and the other two types of institutional ownership.

5.3. Determinants of wealth effects of industry rival firms

In this section, we undertake a more detailed analysis of the wealth effects of product recalls on the firm’s rivals. We estimate weighted least squares regressions to explain the announcement period abnormal returns of rivals using factors we expect can affect the returns in a multivariate setting. We report two regression specifications in Table 9; one where the dependent variable is the abnormal returns of the rivals measured over the (–5, +5) window and the other where it is measured over the (–10, +10) window. If the product recall is associated with a negative wealth effect on the recalling firm, we expect that to affect its industry-rival firms either positively (competitive effect) or negatively (contagion effect). If the competitive effect is dominant, then we would expect the coefficient on the recalling firm abnormal returns to be negative. That is, we would expect negative recalling firm returns to be met with positive rival abnormal returns since the recall gives the rivals a competitive advantage. Conversely, the coefficient would be positive if the contagion effect were to dominate.

In the estimated regressions, we also examine whether financial constraints of the recalling firm, the brand capital of the recalling firm, and whether this is the first recall by the firm all affect the wealth effects for the rival firms. We expect that rivals of financially constrained recalling firms and rivals of recalling firms with low brand image to benefit more from the recall since predation of such recalling firms and appropriation of their sales by these rivals is easier following recalls. Thus, we expect the *KZ index* of the recalling firm to have a positive coefficient and *Brand capital* of the recalling firm to have a negative coefficient in the rival abnormal returns regressions. If the first recall by a firm is viewed as a one-off problem with no long-term consequence, then we expect that the dummy variable identifying the first recall will have a negative coefficient in explaining rival returns. On the other hand, if the first recall by a firm is viewed especially negatively, i.e., as an indication of future problems to come, then it will be construed as more good news for the rivals and we will expect a positive coefficient on the dummy variable.[16] We use size of the recalling firm (*Size*) as a control variable in our regressions.

The results in Table 9 indicate that recalling firm CARs are significantly and positively related to rival firm CARs. This is true in both the (–5, +5) and the (–10, +10) announcement-period windows. These results are consistent with the view that the contagion effects dominate in product recalls. Bad news for the recalling firm is viewed as bad news for the rivals too as there are significant spillover

[16] Of course, this expectation about the information conveyed by the first recall assumes that the "competitive" effect is dominant. If, however, the contagion effect is in play, then what is bad news for the recalling firm will also be bad news for the rival firm.

effects possibly in the form of increased regulatory scrutiny for the industry as a whole and possible adverse or costly changes to the processes within the industry.

The *KZ index* has a positive coefficient in both regressions, but is statistically significant only in the longer window announcement returns. This weakly suggests that more financial constraints for the recalling firm do have a positive wealth effect on the rival firms, perhaps because predation of a financially constrained industry competitor is easier. Similarly, the initial recall dummy is positive in both regressions, but is statistically significant in only the first one. Again, the evidence is weakly consistent with the view that initial recalls are viewed positively for the rivals especially after controlling for any contagion effects that may be captured by the coefficient on the recalling firm CARs in the regression. None of the other variables, including *Brand capital*, have a significant role in explaining the rival returns. Overall, the results are consistent with the view that there is contagion, i.e., announcements of product recalls that have more negative consequences for the recalling firms tend to have more negative implications for the rivals as well.

5.4. Determinants of wealth effects of key supplier firms

In this section, we examine the determinants of the wealth effects of key supplier firms to announcements of the product recall by a given firm. Here too we estimate weighted least squares regressions to explain the announcement period abnormal returns of key suppliers using factors we expect can affect these returns in a multivariate setting. We report 4 models in Table 10. In Models 1 and 3, the dependent variable is the abnormal returns of the key suppliers measured over the (–5, +5) window and, in Models 2 and 4, the dependent variable is the abnormal returns of the key suppliers measured over the (–10, +10) window.

We include the recalling firm's abnormal returns measured over the same window as its key suppliers' abnormal returns. Including this variable allows us to distinguish between whether the spillover to the supply chain can be attributable to contagion or competitive effects. If the spillovers are due to contagion, then there should be a positive relation between the abnormal returns to the key suppliers and the abnormal returns to the recalling firm. On the other hand, if the spillovers are due to competitive effects, the relation between the abnormal returns to the key supplier firms and the recalling firm depends on how easy is it for key suppliers to switch their sales to alternative customer firms. If switching costs are small, then these key suppliers can switch and sell instead to industry rival firms in which case there should be no relation between the abnormal returns to key supplier firms and the abnormal returns to the recalling firms. On the other hand, if switching costs are high, then we should again find a positive relation between the abnormal returns to key suppliers firms and the recalling firms.

If *Brand capital* can somewhat insulate the recalling firms from the adverse consequences of the recall event, then it should also reduce the disruptions faced by key suppliers to the recalling firms. Thus, we predict a positive relation between the abnormal returns to the key supplier firms and the *Brand capital* of the recalling firm. The more financially constrained the recalling firm, the lesser is its flexibility and ability to deal with the recall event. As a consequence, its key suppliers will also be affected by its inability to fully deal with the aftermath of the product recall announcement. We, therefore, hypothesize that there should be a negative relation between the abnormal returns to the key supplier firms and the *KZ index* of the recalling firm.

R&D intensity has been used in the extant product markets literature as a proxy for relationship-specific investments (e.g., Allen and Phillips, 2000; Fee, Hadlock, and Thomas, 2006; Kale and Shahrur, 2007; and Jain, Kini, and Shenoy, 2011). Thus, if the recalling firm's key suppliers have greater *R&D intensity*, then it is likely that they have invested heavily in investments that are specific to the recalling firm. As such, if a negative event like a product recall affects an important customer firm, then switching to an industry rival of the recalling firm is costly due to these relationship-specific investments. The inability to easily switch customers due to these investments implies that any negative shock to an important customer firm will adversely affect key suppliers too. This leads to the prediction that the announcement period abnormal returns of key supplier firms will be negatively related to their R&D intensity. As in Tables 8 and 9, the *Initial recall dummy* and *Size* are control variables in Table 10 too.

We find that the coefficient on the abnormal returns to the recalling firms is significantly positive at the 1% level in all four estimated models. In light of the fact that we document a positive relation between the abnormal returns to the industry rival firms and the recalling firm's abnormal returns, this result is consistent with the idea that the spillover effect, on average, is attributable to contagion. The coefficients on both *Brand capital* and *KZ index* are insignificant in Models 1 and 2. We, therefore, do not include them in Models 3 and 4 because they will just add noise to these models. The coefficient on *Supplier R&D intensity* is significantly negative at the 5% level in both Models 3 and 4, thereby suggesting that key suppliers who make greater relationship specific investments in the recalling firm are more adversely affected by the announcement of the product recall.

6. Changes in firm performance/policies around recall incidence

In this section, we investigate the changes in firm policies and firm performance around the occurrence of product recall events to get some flavor for the nature of recall costs. In particular, we study the impact of product recalls on sales of firms and subsequent corporate decisions such as capital expenditures, operating expenditures, R&D expenditures, advertising expenditures, selling, general and administrative expenditures, accounts receivables, accounts payables, and inventory turnover.

To account for the endogeneity of a recall event, we use the propensity score matching (e.g., Rosenbaum and Rubin, 1983) and the Abadie and Imbens matching (e.g., Abadie and Imbens, 2006; Abadie, Drukker, Herr, and Imbens, 2004) methodologies. Both methodologies assume that the assignment of firms into the treatment group (recalling firms) and control group (non-recalling firms) is non-random and this leads to a sample selection bias. They attempt to reduce the extent of this selection bias by controlling for observable factors that explain the assignment into the treatment and control groups and estimating the average treatment of the treated (ATT) effect. The propensity score matching method proposes to summarize the pre-treatment characteristics of each observation into a single-index variable, the propensity score, and the matching is based on this variable. The Abadie and Imbens matching is based on the estimators developed in Abadie and Imbens (2006) conditional on a set of control variables. One unique feature of this estimator is that is allows the researcher to specify exact matching on one or more variables that are not in the list of observables. In our context, it lets us to pick a control firm that matches the recalling firm's three-digit SIC industry. The Abadie and Imbens matching estimator also lets us use heteroskedasticity-consistent standard errors.

To implement the matching methodologies, we run a first stage probit estimation model where we model recall incidence (*RecallDum*) as in Equation 1. We measure the change in corporate policy or firm performance as the difference between the policy variable for year *t+1* (average of years *t+1* and *t+2*) and the policy variable for year *t-1* (average of years *t-1* and *t-2*), where year t is the recall announcement year. Furthermore, since corporate policy or firm performance variables are reported on an annual basis on the Compustat database, we reduce recall events in our sample into recalling firm-year observations. In this approach, multiple recall events by a firm in a single year will be collapsed into one recalling firm-year observation. Finally, we exclude contaminating recalling firm-year observations from our sample. In particular, we delete a recalling firm-year (year *t*) from the sample if the same firm had a recall event in year *t-1* or year *t+1*. Through this approach we obtain a clean pre-event and post-event window over which to measure changes in corporate policies that happen around a recall event. For example, if the recalling firm in year *t* had a recall announcement in year *t-1* (*t+1*) as well, then the policy variables measured in year *t-1* (*t+1*) can be possibly contaminated by the recall in *t-1* (*t+1*) which makes drawing inferences hard. By adopting the above criteria we seek to identify a sample of recall events where we can cleanly measure the corporate policy variables before the recall event (year *t-1*) and after the recalling event (year *t+1*) when variables in years *t-1* and *t+1* themselves were not affected by a recall event.

We report results for the changes in corporate policies and firm performance around recall events in Table 11. In the propensity score matching and Abadie and Imbens matching, we match each observation in the treatment group with four nearest neighbors from the control group of observations and we match with replacement. In Panel A, we report the results for the corporate policy changes measured from year *t-1* to year *t+1* where year *t* is the recall announcement year. In Panel B, we report the results for the corporate policy changes measured as the average of year *t-1* and *t-2* compared to average of year *t+1* and *t+2*. The column *Difference* represents the average treatment effect of the treated (ATT) or the difference-in-differences between the treated and control groups. Finally, as a baseline specification, we also report results based on ordinary least squares (OLS) estimations in both Panels A and B. In all OLS estimations we include year and industry dummy variables and reported t-statistics are based on robust standard errors and are clustered at the firm level.

In Panels A and B, we find that recalling firms experience a decline in sales relative to the nearest matched control firms and that the effect is statistically significant. For example, in Panel A, we find that the sales growth (from *t-1* to *t+1*) for recalling firms was 11.45% lower than the sales growth for the nearest matching control firms. The difference-in-differences is found to be statistically significant at the 5% level. Qualitatively similar results are found in Panel B. These results demonstrate that there are negative real consequences to firms that experience quality failures. As such, these results further corroborate our earlier finding of announcement-period value losses for recalling firm shareholders. Furthermore, in both Panels A and B, we find that recalling firms increase their advertising expenditures relative to the nearest matched control firms and that the effect is statistically significant. For example, in Panel A, we find that the change in advertising intensity (from *t-1* to *t+1*) for recalling firms is 0.27% higher than the change in advertising intensity for the nearest matched control firms. As such, these findings suggest that recalling firms respond to the product crisis by increasing their advertising expenditures relative to control firms, thus indicating that they are attempting to repair their tarnished brand image by proactively increasing investments in brand capital and, at the same time, preventing existing rivals and new entrants from gaining market share at their expense.[17]

In addition to the above documented effects on sales growth and advertising intensity, we examine several other corporate policy variables such as R&D intensity, capital expenditure intensity, sales, general, and administrative expenditures, operating expenses, accounts receivables to sales, accounts payables-to-cost of goods sold, and inventory-to-cost of goods sold. We, however, are unable to obtain a set of consistent results across the propensity score matching, Abadie and Imbens matching, and OLS estimations. Therefore, the evidence on the change in other policy variables remains inconclusive.

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[17] In a survey of product managers of major corporations, Smiley (1980) documents that 78% of respondents stated that advertising was used as a mechanism to deter entry for both new and existing product lines.

7. Summary and conclusions

In this paper, we study: (i) the factors that explain the incidence of product recalls, (ii) the value implications of the recall announcements on the recalling firms, their industry rivals, and the key suppliers of the recalling firms, and (iii) the actions taken by the recalling firms in response to the recall. To analyze our hypotheses, we collect data on product recall campaigns announced by publicly traded firms during the period 2006 - 2010. Our final sample comprises of 816 recalls events including consumer product recalls, food, drug and medical device recalls, and automobile recalls.

Overall, the key implications of our study are that product recalls are material episodes in the life a firm. There are fundamental primitives, such as the financial health of the firm, competition in the industry, unionization status of the work force, the coordination costs in the production process, managerial incentives, and institutional shareholder monitoring, that play a significant role in affecting product quality failures and the incidence of product recalls. A recall is bad news not only for the recalling firm but also for the firms' key suppliers and, to a lesser extent, its industry-rival firms. The contagion effect on both the firm's industry rivals and its key suppliers is more severe if the recalling firm is more adversely impacted by the recall. The negative impact of a product recall on the recalling firm is alleviated if the firm has greater investment in brand capital. The negative consequences for key supplier firms are worse if their relationship-specific investments are higher. Recalls also lead to decreased sales subsequent to the event and cause firms to incur significantly more advertising expenditures to salvage some of their brand value and image.

The contributions of this study are multifaceted. First, the study fills in existing gaps in the financial economics literature by using the incidence of a product recall as a proxy for quality failure and examining the firm- and industry-specific factors that explain quality failures. It conducts an in-depth examination of the valuation consequences of recall events to the recalling firms, their competitor firms, and key suppliers. It also examines the consequences of a product recall for the operating performance of the firm as well as how firms react to the recall event. The findings from this study have public policy implications because it gives U.S. product safety watchdogs insights that can possibly improve their regulation of product safety practices. Finally, our findings will help firms identify factors that affect recalls so that they can better target the highest acceptable level for the likelihood of a recall.

Appendix

This appendix provides details on the construction of variables used in the paper.

I. *Determinants of recall incidence*

a. *Book* (*market*) *leverage*

Book leverage is the sum of the long-term debt and debt in current liabilities (Compustat item *DLTT* + Compustat item *DLC*) divided by total assets (Compustat item *AT*) for the year prior to the year of announcement. For Market leverage, instead of dividing the numerator by *AT* we divide it by the sum of the book value of debt (Compustat item *DLTT* + Compustat item *DLC*) and market value of equity (Compustat item *CSHO* x Compustat item *PRCC_F*) for the year prior to the year of announcement.

b. *Altman Z-Score*

Altman *Z* is the Altman Z-score score developed in Altman (1968). It is calculated as 3.3*(Compustat item *EBIT*/Compustat item *AT*) + (Compustat item *REVT*/Compustat item *AT*) + 1.4*(Compustat item *RE*/Compustat item *AT*) + 1.2*([Compustat item *ACT* – Compustat item *LCT*]/Compustat item *AT*) + 0.6*([Compustat item *CSHO* x Compustat item *PRCC_F*]/Compustat item *LT*). All Compustat items are measured for the year prior to year of announcement.

c. *KZ index*

KZ index is the Kaplan and Zingales (1997) measure of financial constraints using the coefficients from Lamont, Polk, and Saá-Requejo (2001). It is calculated as -1.001909*([Compustat item *DP* + Compustat item *IB*]/Compustat item *PPENT*) + 0.2826389*([Compustat item *AT* + Compustat item *CSHO* x Compustat item *PRCC_F* - Compustat item *SEQ* + Compustat item *TXDB*]/ Compustat item *AT*) + 3.139193*([Compustat item *DLC*+ Compustat item *DLTT*]/[Compustat item *DLTT*+ Compustat item *DLC*+ Compustat item *SEQ*]) - 39.3678*([Compustat item *DVC* + Compustat item *DVP*]/ Compustat item *PPENT*) - 1.314759*(Compustat item *CH*/ Compustat item *PPENT*). All Compustat items are measured for the year prior to year of announcement.

d. Number of suppliers

Number of Suppliers is the number of key suppliers of the firm as identified in the Compustat segment tapes. FASB requires that firms report the names of customers that account for at least 10% of their sales and this information is available on the Compustat database. We use this Compustat data to identify the suppliers for all firms in Compustat database. Using this data, we then generate the number of suppliers for our sample firms for the year prior to the year of announcement.

e. Vertical integration dummy

Vertical integration dummy is an indicator variable that is set to 1 if any two segments of the firm share a vertical supply relation of 5% or more and 0 otherwise. To identify vertical relatedness between sample industries, we use the 2002 benchmark input-output tables of the U.S. economy published by the Bureau of Economic Analysis.

f. Capital-to-labor intensity

Labor intensity is the ratio of capital-to-labor in the production process. It is measured as the ratio of property, plant, and equipment (Compustat item *PPENT*) to the number of employees (Compustat item *EMP*). All Compustat items are measured for the year prior to year of recall announcement.

g. COGS-to-Sales

Is measured as the ratio of the cost of goods sold (Compustat item *COGS*) to revenues (Compustat item *REVT*). All Compustat items are measured for the year prior to year of recall announcement.

h. R&D intensity

Is measured as the ratio of the research & development expenditure (Compustat item *XRD*) to total assets (Compustat item *AT*). All Compustat items are measured for the year prior to year of recall announcement.

i. Total factor productivity

To calculate total factor productivity, we follow the methodology in Faleye, Mehrotra, and Morck (2006). In particular, for each two-digit SIC industry group, we regress the natural logarithm of firm sales (Compustat item *REVT*) on the natural logarithm of number of employees (Compustat item *EMP*) and the natural logarithm of net property, plant, and equipment (Compustat data item *PPENT*). *TFP* is measured as the residual from this regression for the primary two-digit SIC industry group of the firm.

j. *Herfindahl index*

The Compustat sales-based Herfindahl index for the primary three-digit SIC industry of the recalling (control) firm for the year prior to the year of recall announcement.

k. Market share

The market share of the recalling (control) firm in its primary three-digit SIC industry based on Compustat database for the year prior to the year of recall announcement.

l. Unionization

Is the rate of unionization for the primary three-digit SIC industry of the recalling (control) firm for the year prior to the year of recall announcement. The rates of unionization are obtained from *Union Stats* website available at http://www.unionstats.com.

m. Merger intensity

Is the strength of the market for corporate control measured as the fraction of takeover targets in the recalling industry (control industry) in a given year relative to all takeover targets in the economy in that year. Merger intensity is measured for the year prior to the recall announcement year.

n. *Institutional ownership*

To identify the type of institutional investors and the proportion of ownership, we use the classification system in Bushee (1998, 2001). *Transient ownership* is the percentage of institutional ownership that is held by transient institutional investors. *Dedicated* (*Quasi-indexer*) *ownership* is the percentage of institutional ownership that is held by dedicated (quasi-indexing) institutional investors.

o. Managerial incentives

CEO delta is the CEO's total portfolio delta (sensitivity of CEO wealth to stock price changes) and *CEO vega* is the CEO's total portfolio vega (sensitivity of CEO wealth to stock volatility). *Compensation gap* is the difference between CEO's compensation and the total compensation of the median VP. All variables are based on Kini and Williams (2012).

p. Size

Is the logarithm of the market value of equity for the recalling firm (control firm).

II. Additional variables influencing the wealth effects of recalling firms, industry rivals, and key suppliers

a. Brand capital

Brand capital is the logarithm of the investment in brand capital by the recalling firm (control firm) and calculated as per the methodology in Lin, Belo, and Vitorino (2012). In particular, they measure the stock of brand capital from past advertising expenditures (Compustat item *XAD*) using a perpetual inventory method. In our computations, we follow their assumptions of the depreciation rate and growth rate of advertising expenditures.

b. Initial recall dummy

Is a dummy variable that is set to 1 for a recall event that is the first one for a firm during our sample period. All subsequent recalls by a firm are coded as 0.

References

Abadie, A., D. Drukker, J. Herr, and G. Imbens, 2004, Implementing matching estimators for average treatment effects in Stata, *Stata Journal* 4, 290-331.

Abadie, A., and G. Imbens, 2006, Large sample properties of matching estimators for average treatment effects. *Econometrica* 74, 235-267.

Abbott, L., 1955, *Quality and Competition; an Essay in Economic Theory*, New York: Columbia University Press.

Aharony, J. and I. Swary, 1983, Contagion effects of bank failures: Evidence from capital markets, *Journal of Business* 56, 305-322.

Ahmed, P., J. Gardella, and S. Nanda, 2002, Wealth effects of drug withdrawals on firms and their competitors, *Financial Management* 31, 21-41.

Allen, J.W., and G. Phillips, 2000, Corporate equity ownership, strategic alliances, and product market relationships, *Journal of Finance* 55, 2791 – 2815.

Altman, E., 1968, Financial ratios, discriminant analysis and the prediction of corporate bankruptcy, *Journal of Finance* 23, 589-609.

Antell, G., and W. Harris, 2004, *Economics: Institutions and Analysis*, Amsco School Publication, New York, NY.

Baldwin, C.Y., 1983, Productivity and labor unions: An application of the theory of self-enforcing contracts, *Journal of Business* 56, 155-185.

Barber, B.M. and M.N. Darrough, 1996, Product reliability and firm value: The experience of American and Japanese automakers, *Journal of Political Economy* 104, 1084-1099.

Bertrand, M., and A. Schoar, 2003, Managing with style: The effect of managers on firm policies. *Quarterly Journal of Economics* 118, 1169-1208.

Bolton, P., and D. S. Scharfstein, 1990, A theory of predation based on agency problems in financial contracting. *American Economic Review* 80, 93-106.

Booth, J., and D. Deli, 1996, Factors affecting the number of outside directorships held by CEOs, *Journal of Financial Economics* 40, 81-104.

Bronars, S., and D. Deere, 1993a, Union organizing activity, firm growth, and the business cycle, *American Economic Review* 83, 203-220.

Bronars, S., and D. Deere, 1993b, Unionization, incomplete contracting, and capital investment, *Journal of Business* 66, 117-132.

Bushee, B., 1998, The influence of institutional investors on myopic R&D investment behavior, *The Accounting Review* 73, 305-333.

Bushee, B., 2001, Do institutional investors prefer near-term earning over long-run value?, *Contemporary Accounting Research* 18, 207-246.

Chamberlin, E.H., 1933, *The Theory of Monopolistic Competition*, Cambridge Massachusetts: Harvard University Press.

Chang, Y., S. Dasgupta, and G. Hilary, 2010, CEO ability, pay, and firm performance, *Management Science* 56, 1633-1652.

Choi, T.Y., and D.R. Krause, 2006, The supply base and its complexity: Implications for transactions costs, risks, responsiveness, and innovation, *Journal of Operations Management* 24, 637-652.

Choi, C., and T. Murphy, 2012, Twinkie maker Hostess reaches the end of the line, *Associated Press*, November 16.

Coles, J. L., N.D. Daniel, and L. Naveen, 2006, Managerial incentives and risk-taking, *Journal of Financial Economics* 79, 431-468.

Coles, J. L., N.D. Daniel, and L. Naveen, 2008, Boards: Does one size fit all?, *Journal of Financial Economics* 87, 329-356.

Cowherd, D., and D.I. Levine, 1992, Product quality and pay equity between lower-level employees and top management: An investigation of distributive justice theory, *Administrative Science Quarterly* 37, 302-320.

Daughety, A.F., and J.F. Reinganum, 1995, Product safety: Liability, R&D, and signaling, *American Economic Review* 85, 1187-1206.

Dowdell, T.D., S. Govindaraj, and P.C. Jain, 1992, The Tylenol incident, ensuing regulation, and stock prices, *Journal of Financial and Quantitative Analysis* 27, 283-301.

Faleye, O., V. Mehrotra, and R. Morck, 2006, When labor has a voice in corporate government, *Journal of Financial and Quantitative Analysis* 41, 489-510.

Fee, C. E., C.J. Hadlock, and S. Thomas, 2006, Corporate equity ownership and the governance of product market relationships, *Journal of Finance* 61, 1217 – 1251.

Gabaix, X., and A. Landier, 2008, Why has CEO pay increased so much? *Quarterly Journal of Economics* 123, 49-100.

Grafton, S.M., G.E. Hoffer, and R.J. Reilly, 1981, Testing the impact of recalls on the demand for automobiles, *Economic Inquiry* 19, 694-703.

Hall, B., and J. Liebman, 1998, Are CEOs really paid like bureaucrats? *Quarterly Journal of Economics* 113, 653-691.

Hertzel, M. G.; Z. Li; M.S. Officer; and K.J. Rodgers, 2008, Inter-firm linkages and the wealth effects of financial distress along the supply chain, *Journal of Financial Economics* 87, 374-387.

Hoffer, G.E., S.W. Pruitt, and R.J. Reilly, 1988, The impact of product recalls on the wealth of sellers: A reexamination, *Journal of Political Economy* 96, 663-670.

Holmstrom, B., and R. Costa, 1986, Managerial incentives and capital management, *Quarterly Journal of Economics* 101, 835-860.

Jain, B.A., O. Kini, and J. Shenoy, 2011, Vertical divestitures through equity carve-outs and spin-offs: A product markets perspective, *Journal of Financial Economics* 100, 594-615.

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

Jensen, M.C., 1986, Agency costs of free cash flow, corporate finance and takeovers, *American Economic Review* 76, 323-329.

Jensen, M.C., and K. Murphy, 1990, Performance pay and top management incentives, *Journal of Political Economy* 98, 225-264.

Kale, J.R., E. Reis, and A. Venkateswaran, 2009, Rank-order tournaments and incentive alignment: The effect on firm performance. *Journal of Finance* 64, 1479-1512.

Kale, K.R. and H. Shahrur, 2007, Corporate capital structure and the characteristics of suppliers and customers, *Journal of Financial Economics* 83, 321-365.

Kaplan, S., and L. Zingales, 1997, Do financing constraints explain why investment is correlated with cash flow? *Quarterly Journal of Economics* 112, 169-215.

Karpoff, J.M., and J.R. Lott, Jr., 1993, The reputational penalty firms bear from committing criminal fraud, *Journal of Law and Economics* 36, 757-802.

Kekre, S., B.P.S. Murthi, and K. Srinivasan, 1995, Operating decisions, supplier availability and quality, *Journal of Operations Management* 12, 387-396.

Kini, O., and R. Williams, 2012, Tournament incentives, firm risk, and corporate policies, *Journal of Financial Economics* 103, 350-376.

Klein, B., R. Crawford, and A. Alchian, 1978, Vertical integration, appropriable rents, and the competitive contracting process, *Journal of Law and Economics* 21, 297-326.

Klein, B., and K. Leffler, 1981, The role of market forces in assuring contractual performance, *Journal of Political Economy* 89, 615-641.

Lamont, O., C. Polk, and J. Saá-Requejo, 2001, Financial constraints and stock returns, *Review of Financial Studies* 14, 529-544.

Lang, L., and R. Stulz, 1992, Contagion and competitive intra-industry effects of bankruptcy announcements, *Journal of Financial Economics* 32, 45-60.

Lin, X., F. Belo, and M.A. Vitorino, 2012, Brand capital and firm value, <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2024182>.

Maksimovic, V., 1995, Financial structure and product market competition, In *Finance: Handbooks in Operations Research and Management Science, Vol. 9*, R. Jarrow, V. Maksimovic, and W.T. Ziemba, eds., Amsterdam: North-Holland.

Maksimovic, V., and S. Titman, 1991, Financial policy and reputation for product quality, *Review of Financial Studies* 4, 175-200.

Matsa, D., 2011a, Competition and product quality in the supermarket industry, *Quarterly Journal of Economics* 126, 1539-1591.

Matsa, D., 2011b, Running on empty? Financial leverage and product quality in the supermarket industry, *American Economic Journal: Microeconomics* 3, 137-173.

Mazzeo, M.J. 2003, Competition and Service Quality in the U S Airline Industry, *Review of Industrial Organization* 22, 275-296.

Meulbroek, L., M. Mitchell, J. Mulherin, J. Netter, and A. Poulsen, 1990, Shark repellents and managerial myopia: An empirical test, *Journal of Political Economy* 98, 1108-1117.

Olmos, D., 2010, April 15, Boston Scientific's heart device recall apt to cost it market share, *The Boston Globe*.

Phillips, G., and G. Sertsios, 2012, How do firm financial conditions affect product quality and pricing?, *Management Science, forthcoming*.

Reilly, R.J., and G.E. Hoffer, 1983, Will retarding the information flow on automobile recalls affect consumer demand? *Economic Inquiry* 21, 444-447.

Rosen, Sherwin, 1969, Trade union power, threat effects, and the extent of organization, *Review of Economic Studies* 36, 185-196.

Rosenbaum, P., and D. Rubin, 1983, The central role of the propensity score in observational studies for causal effects, *Biometrika* 70, 41-55.

Ross, S.A., R.W. Westerfield, and J.F. Jaffe, 2008, *Corporate Finance*, New York, NY: McGraw-Hill Irwin.

Ruback, R., and M. Zimmerman, 1984, Unionization and Profitability: Evidence from the capital market, *Journal of Political Economy* 92, 1134-1157.

Shin, H., D.A. Collier, and D.D. Wilson, 2000, Supply management orientation and supplier/buyer performance, *Journal of Operations Management* 18, 317-333.

Smiley, R., 1988, Empirical evidence on strategic entry deterrence, *International Journal of Industrial Organization* 6, 167-180.

Sutton, J., 2007, Quality, trade and the moving window: The globalization process, *The Economic Journal* 117, F469-F498.

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

Treleven, M., 1987, Single sourcing: A management tool for the quality supplier, *Journal of Purchasing and Materials Management* 23, 19-24.

Treleven, M., and S.B. Schweikhart, 1988, A risk/benefit analysis of sourcing strategies: Single vs. multiple sourcing, *Journal of Operations Management* 7, 93-114.

Waldman, D.E., and E.J. Jensen, 2007, *Industrial organization: Theory and practice*, Boston, MA: Pearson Addison Wesley.

Table 1
Frequency of recall events

This table presents the frequency of recall events by public firms during our sample period of 2006 – 2010. The table reports recalls in the food, drug, and medical device industries covered by the Food and Drug Administration (*FDA*), the Consumer Product Safety Commission (*CPSC*), and the National Highway Traffic Safety Administration (*NHTSA*).

	Number of observations			
Year of recall	*FDA*	*CPSC*	*NHTSA*	Overall
2006	58	65	39	162
2007	60	96	31	187
2008	63	57	21	141
2009	90	49	15	154
2010	85	54	33	172
Total	356	321	139	816

Table 2
Industries covered in recall sample

This table presents the different two-digit SIC industries covered in our recall sample and the number of recalls under each two-digit SIC industry. The sample period is 2006 – 2010. The table covers recalls in the food, drug, and medical device industries covered by the Food and Drug Administration (*FDA*), the Consumer Product Safety Commission (*CPSC*), and the National Highway Traffic Safety Administration (*NHTSA*).

Two-digit SIC Code	Description of industry	Number of recalls
1	Agricultural Production Crops	3
2	Agriculture production livestock and animal specialties	2
20	Food And Kindred Products	98
23	Apparel And Other Finished Products Made From Fabrics	4
24	Lumber And Wood Products, Except Furniture	1
25	Furniture And Fixtures	4
27	Printing, Publishing, And Allied Industries	3
28	Chemicals And Allied Products	140
29	Petroleum Refining And Related Industries	1
30	Rubber And Miscellaneous Plastics Products	8
31	Leather And Leather Products	4
32	Stone, Clay, Glass, And Concrete Products	1
34	Fabricated Metal Products, Except Machinery And Transportation Equipment	13
35	Industrial And Commercial Machinery And Computer Equipment	41
36	Electronic & Other Electrical Equipment And Components, Except Computer Equipment	41
37	Transportation Equipment	159
38	Measuring, Analyzing, And Controlling Instruments	73
39	Miscellaneous Manufacturing Industries	37
47	Transportation Services	1
48	Communications	4
50	Wholesale Trade-durable Goods	4
51	Wholesale Trade-non-durable Goods	3
52	Building Materials, Hardware, Garden Supply, And Mobile Home Dealers	4
53	General Merchandise Stores	51
54	Food Stores	40
55	Automotive Dealers And Gasoline Service Stations	1
56	Apparel And Accessory Stores	18
57	Home Furniture, Furnishings, And Equipment Stores	22
58	Eating And Drinking Places	7
59	Miscellaneous Retail	10
73	Business Services	1
80	Health Services	2
99	Non-classifiable Establishments	15

Table 3
Announcement period wealth effects for recalling firms

This table presents the announcement period wealth effects of the recall events for the recalling firms. The sample period is 2006 – 2010 and contains recalls in the food, drug, and medical device industries covered by the Food and Drug Administration (*FDA*), the Consumer Product Safety Commission (*CPSC*), and the National Highway Traffic Safety Administration (*NHTSA*). *CAR* (%) is the average cumulative abnormal return for the recalling firm over the event window. Z statistics are used to test if the mean cumulative abnormal returns are statistically different from zero and are provided in the parentheses. *% Positive* represents the proportion of recalling firms that have positive returns. A generalized sign test is performed to test their statistical significance. *Dollars* presents the mean and median dollar wealth effect of the recall announcement and is measured in millions of dollars, with median numbers reported in square brackets. It is calculated as the product of the announcement period cumulative abnormal return and the market capitalization of the recalling firm prior to the announcement date. N is the number of recall events in sample. The table report results for the overall sample of recalls, and different sub-samples such as the *FDA*, *CPSC*, and *NHTSA* respectively. ***, ** and * indicate significance at 1%, 5%, and 10% respectively.

	Overall N=816			*FDA* N=356			*CPSC* N=321			*NHTSA* N=139		
Event windows	*CAR* (%)	*% Positive*	*Dollars* (mil)	*CAR* (%)	*% Positive*	*Dollars* (mil)	*CAR* (%)	*% Positive*	*Dollars* (mil)	*CAR* (%)	*% Positive*	*Dollars* (mil)
(-2, +2)	-0.97***	39.58***	-171.92	-0.96***	41.29**	-162.16	-1.25	36.13***	-224.89	-0.34	43.17	-74.98
	(-6.01)	(-4.82)	[-17.13]	(-4.21)	(-2.66)	[-17.52]	(-4.34)	(-4.26)	[-16.22]	(-1.25)	(-0.95)	[-20.03]
(-5, +5)	-1.72***	37.50***	-302.27	-1.57***	39.60***	-320.73	-2.42***	31.46***	-393.05	-0.36	46.04	-46.00
	(-7.87)	(-6.01)	[-37.66]	(-4.79)	(-3.29)	[-41.01]	(-6.59)	(-5.93)	[-40.53]	(-1.38)	(-0.28)	[-11.48]
(-10, +10)	-2.23***	37.62***	-521.96	-1.71***	38.48***	-638.49	-3.22***	35.20***	-499.91	-1.29***	41.00	-274.29
	(-8.25)	(-5.94)	[-68.46]	(-5.02)	(-3.72)	[-73.33]	(-6.08)	(-4.59)	[-64.08]	(-2.71)	(-1.46)	[-83.29]
(-10, +2)	-1.78***	37.38***	-339.17	-1.31***	40.44***	-309.07	-2.56***	33.02***	-475.23	-1.20**	39.57*	-103.02
	(-7.33)	(-6.08)	[-51.31]	(-4.02)	(-2.98)	[-40.31]	(-5.75)	(-5.37)	[-56.18]	(-2.58)	(-1.80)	[-62.48]
(-20, +20)	-2.82***	39.71***	-380.25	-1.84***	38.48***	-654.56	-3.92***	36.76***	-78.30	-2.81***	46.04	-372.86
	(-6.78)	(-4.75)	[-56.22]	(-4.33)	(-3.72)	[-95.59]	(-4.44)	(-4.03)	[-50.83]	(-2.70)	(-1.46)	[-23.12]

Table 4

Univariate comparisons between recalling firms and control firms

This table presents the univariate comparisons between recalling firms and control firms. The sample period is 2006 – 2010 and contains recalls in the food, drug, and medical device industries covered by the Food and Drug Administration (*FDA*), the Consumer Product Safety Commission (*CPSC*), and the National Highway Traffic Safety Administration (*NHTSA*). Control firms are firms that belong to the same three-digit SIC industry as the recalling firm provided they did not have a recall during 2006 – 2010. *Book (Market) leverage* is the book (market) value of debt divided by total assets. *Altman Z* is the Altman Z-score score used in Altman (1968) and is calculated as 3.3*EBIT/Total assets + Sales/Total assets + 1.4*Retained earnings/Total assets + 1.2*Working capital/Total assets + 0.6*Market value of equity/Total Liabilities. *KZ index* is the Kaplan and Zingales (1997) measure of financial constraints using the coefficients from Lamont, Polk, and Saá-Requejo (2001). *COGS-to-Sales* is the ratio of the cost of goods sold (COGS) to revenues (REVT). Number of Suppliers is the number of key suppliers of the firm as identified in the Compustat segment tapes. *Vertical integration dummy* is an indicator variable that is set to 1 if any two segments of the firm share a vertical relation of 5% or more, and 0 otherwise based on the benchmark input-output tables of the U.S. economy. *Unionization* is the percentage of employees in the industry that are unionized. *Capital-to-labor intensity* is the ratio of property, plant, and equipment (PPENT) to the number of employees (EMP). *Market Share* is a firm's sales divided by the total sales in its primary three-digit SIC industry. *Herfindahl Index* is the sales-based Herfindahl index of the three-digit SIC industry of the firm. *R&D intensity* is the research & development expenditure (XRD) divided by book value of assets (AT). *Total factor productivity* is calculated as the residual from a regression of logarithm of firm sales on the logarithm of number of employees and logarithm of property, plant, and equipment where regressions are run by two-digit SIC industry and year. *Merger intensity* is measured as the number of takeovers in which firms in the recall (control) industry were targets divided by the total number of takeovers in the economy during that year. *Size* is the lagged logarithm of the market value of equity. *Compensation gap* is the difference between CEO's compensation and the compensation of the median VP and are based on Kini and Williams (2012). *CEO delta* is the CEO's total portfolio delta and *CEO vega* is the CEO's total portfolio vega and are based on Kini and Williams (2012). *Transient ownership* is the percentage of institutional ownership that is held by transient institutional investors per Bushee (2001). *Dedicated* (*Quasi-indexer*) *ownership* is the percentage of institutional ownership that is held by dedicated (quasi-indexing) institutional investors per Bushee (2001). *T (Z)* Stat provides the t-statistic (z-statistic) for the difference in means and medians, respectively. The t-statistic is based on a t-test for the equality of means and the z-statistic is based on a Wilcoxon rank-sum test for the equality of medians. ***, ** and * indicate significance at 1%, 5%, and 10% respectively.

Panel A: Firm and industry level variables

Variable name	Recall sample			Control sample			
	N	Mean	Median	N	Mean	Median	*T (Z)* Stat
Book leverage	796	0.267	0.260	11,283	0.155	0.072	15.07*** (21.09***)
Market leverage	796	0.258	0.199	11,276	0.138	0.045	16.62*** (20.28***)
Altman Z	796	3.64	3.12	11,217	4.41	3.36	-2.38** (-1.24)
KZ index	796	-3.73	-1.61	11,148	-22.69	-1.53	1.83* (0.92)
Number of suppliers	796	11.43	2.00	11,285	0.56	0.00	43.74*** (44.18***)
Vertical integration dummy	778	0.046	0.000	11,108	0.042	0.000	0.50 (0.50)
Capital-to-labor intensity	783	94.58	63.66	11,111	67.07	26.52	3.41*** (21.67***)
R&D intensity	796	0.031	0.024	11,283	0.107	0.045	-13.18*** (-12.23***)
COGS to Sales	796	0.590	0.624	10,905	0.784	0.600	-5.87*** (1.22)
Total factor productivity	781	-0.113	-0.132	11,107	0.021	0.067	-4.38*** (-8.65***)
Market share	796	0.177	0.119	11,267	0.020	0.001	54.82*** (39.46***)
Herfindahl index	796	0.219	0.169	11,285	0.137	0.078	17.03*** (16.70***)
Unionization	796	11.15	6.00	11,285	5.189	3.300	26.32*** (17.17***)
Merger intensity	796	0.026	0.000	11,285	0.064	0.033	-15.02*** (-18.18***)
Size	796	9.263	9.606	11,276	5.670	5.573	48.72*** (36.81***)

Continued…

Table 4 (continued)

Panel B: Compensation and institutional ownership

Variable name	Recall sample			Control sample			
	N	Mean	Median	N	Mean	Median	
CEO delta	502	0.660	0.445	2,812	0.360	0.145	10.50*** (14.03***)
CEO vega	502	0.532	0.383	2,812	0.212	0.085	18.73*** (17.64***)
Compensation gap	487	8.220	8.375	2,738	7.098	7.154	19.42*** (18.75***)
Transient ownership	642	0.127	0.114	5,895	0.147	0.127	-4.05*** (-2.81***)
Quasi-indexer ownership	645	0.414	0.473	5,946	0.348	0.354	6.81*** (6.59***)
Dedicated ownership	632	0.075	0.059	4,792	0.099	0.078	-6.17*** (-6.10***)

Table 5
Probit regressions: Firm- and industry-specific determinants of recall incidence

This table presents the recall incidence estimation results for recall events by public firms during our sample period of 2006 – 2010. The dependent variable is *RecallDum* which is set to one for firms in the recall sample, and zero for control firms. Control firms are firms that belong to the same three-digit SIC industry as the recalling firm provided they did not have a recall during 2006 – 2010. Recalls in the food, drug, and medical device industries covered by the Food and Drug Administration (*FDA*), the Consumer Product Safety Commission (*CPSC*), and the National Highway Traffic Safety Administration (*NHTSA*) are included in the sample. Panel A contains estimation results when we include calendar year dummies along with our explanatory variables and Panel B contains estimation results when we include industry dummies and calendar year dummies along with our explanatory variables. Marginal effects are reported in the table and reported *p*-values in the parentheses are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10% respectively.

Panel A: Firm and industry level determinants of recall incidence with calendar year dummies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*
Book leverage	0.0161***		0.0161***					
	(0.003)		(0.001)					
Market leverage		0.0215***		0.0217***				
		(0.000)		(0.000)				
Altman Z					-0.0008***	-0.0008***		
					(0.000)	(0.000)		
KZ index							0.0001**	0.0001**
							(0.021)	(0.042)
Number of suppliers	0.0008***	0.0007***	0.0008***	0.0006***	0.0007***	0.0007***	0.0007***	0.0007***
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Vertical integration dummy	-0.0079***	-0.0069***	-0.0074***	-0.0065***	-0.0071***	-0.0067***	-0.0062***	-0.0059***
	(0.008)	(0.006)	(0.007)	(0.005)	(0.004)	(0.003)	(0.008)	(0.007)
Capital-to-labor intensity x 1,000	-0.0461***	-0.0432***	-0.0460***	-0.0426***	-0.0394***	-0.0392***	-0.0361***	-0.0362***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R&D intensity	-0.0454**	-0.0360*	-0.0354*	-0.0260	-0.0512***	-0.0425**	-0.0435**	-0.0358**
	(0.045)	(0.083)	(0.090)	(0.170)	(0.009)	(0.021)	(0.019)	(0.043)
COGS-to-Sales	-0.0176***	-0.0189***	-0.0142**	-0.0158***	-0.0198***	-0.0171***	-0.0155***	-0.0129***
	(0.004)	(0.001)	(0.014)	(0.003)	(0.000)	(0.001)	(0.002)	(0.007)

Continued…

Table 5, Panel A (continued)								
Total factor productivity	-0.0061***	-0.0050***	-0.0060***	-0.0050***	-0.0048***	-0.0049***	-0.0045***	-0.0045***
	(0.001)	(0.003)	(0.001)	(0.002)	(0.004)	(0.002)	(0.003)	(0.002)
Market share	0.0348***	0.0302***			0.0275***		0.0283***	
	(0.004)	(0.005)			(0.009)		(0.004)	
Herfindahl index			0.0284***	0.0258***		0.0233***		0.0225***
			(0.000)	(0.000)		(0.000)		(0.000)
Unionization	0.0010***	0.0009***	0.0009***	0.0007***	0.0009***	0.0008***	0.0008***	0.0008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Merger intensity	-0.0559**	-0.0507**	-0.0448*	-0.0392*	-0.0537***	-0.0438**	-0.0459**	-0.0385**
	(0.019)	(0.015)	(0.053)	(0.053)	(0.008)	(0.028)	(0.015)	(0.039)
Size	0.0075***	0.0070***	0.0083***	0.0076***	0.0068***	0.0074***	0.0061***	0.0067***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Calendar year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,327	11,327	11,327	11,327	11,278	11,278	11,312	11,312

Panel B: Firm and industry level determinants of recall incidence with industry and calendar year dummies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*
Book leverage	0.0078***		0.0072***					
	(0.009)		(0.002)					
Market leverage		0.0133***		0.0123***				
		(0.000)		(0.000)				
Altman Z					-0.0005***	-0.0005***		
					(0.000)	(0.000)		
KZ index							0.0000	0.0000
							(0.179)	(0.188)
Number of suppliers	0.0005***	0.0004***	0.0004***	0.0003***	0.0004***	0.0004***	0.0004***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Vertical integration dummy	-0.0028	-0.0028*	-0.0021	-0.0020	-0.0027*	-0.0021*	-0.0026	-0.0019
	(0.118)	(0.093)	(0.149)	(0.113)	(0.082)	(0.095)	(0.110)	(0.138)

Continued…

Table 5, Panel B (continued)								
Capital-to-labor intensity x 1000	-0.0213***	-0.0233***	-0.0162***	-0.0176***	-0.0182***	-0.0137**	-0.01862***	-0.0142**
	(0.007)	(0.004)	(0.008)	(0.005)	(0.008)	(0.012)	(0.008)	(0.011)
R&D intensity	-0.0310***	-0.0234**	-0.0234**	-0.0158*	-0.0315***	-0.0242***	-0.0303***	-0.0235**
	(0.010)	(0.030)	(0.021)	(0.070)	(0.002)	(0.005)	(0.008)	(0.016)
COGS-to-Sales	-0.0027**	-0.0030**	-0.0017*	-0.0019*	-0.0036**	-0.0025**	-0.0026**	-0.0016*
	(0.032)	(0.034)	(0.087)	(0.065)	(0.029)	(0.036)	(0.034)	(0.090)
Total factor productivity	-0.0024***	-0.0021**	-0.0020***	-0.0017**	-0.0019**	-0.0016**	-0.0021**	-0.0017**
	(0.008)	(0.018)	(0.007)	(0.018)	(0.025)	(0.024)	(0.011)	(0.011)
Market share	0.0172**	0.0154**			0.0139**		0.0158**	
	(0.012)	(0.016)			(0.023)		(0.011)	
Herfindahl index			0.0172***	0.0172***		0.0152***		0.0152***
			(0.000)	(0.000)		(0.000)		(0.000)
Unionization	0.0006***	0.0005***	0.0004***	0.0004***	0.0005***	0.0004***	0.0005***	0.0004***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Merger intensity	0.0613***	0.0598***	0.0668***	0.0671***	0.0586***	0.0644***	0.0537***	0.0575***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.002)	(0.000)
Size	0.0041***	0.0043***	0.0039***	0.0039***	0.0039***	0.0036***	0.0038***	0.0036***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Calendar year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,305	11,305	11,305	11,305	11,256	11,256	11,290	11,290

Table 6
Probit regressions: Governance variables affecting recall incidence

This table presents the recall incidence estimations results when we include compensation and institutional ownership variables in addition to the variables outlined in Table 5. The dependent variable is *RecallDum* which is set to one for firms in the recall sample and zero for control firms. Control firms are firms that belong to the same three-digit SIC industry as the recalling firm provided they did not have a recall during 2006 – 2010. Recalls in the food, drug, and medical device industries covered by the Food and Drug Administration (*FDA*), the Consumer Product Safety Commission (*CPSC*), and the National Highway Traffic Safety Administration (*NHTSA*) are included in the sample. Models 1 and 2 contain estimation results when we include calendar year dummies and models 3 and 4 contain estimation results when we include industry dummies and calendar year dummies along with our explanatory variables. The sample of recalling firms and control firms used in these models have compensation data available on ExecuComp. Marginal effects are reported in the table and reported *p*-values in the parentheses are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10% respectively.

	(1)	(2)	(3)	(4)
Dependent variable	*RecallDum*	*RecallDum*	*RecallDum*	*RecallDum*
Compensation and institutional ownership variables				
CEO delta	-0.0076	-0.0183	-0.0211	-0.0273
	(0.826)	(0.537)	(0.545)	(0.415)
CEO vega	0.0744	0.0765	0.1030	0.1039*
	(0.193)	(0.139)	(0.117)	(0.095)
Compensation gap	0.0272**	0.0245**	0.0359**	0.0331**
	(0.025)	(0.037)	(0.020)	(0.025)
Transient ownership	-0.0653	-0.0624	-0.1284	-0.1130
	(0.549)	(0.562)	(0.358)	(0.405)
Quasi-indexer ownership	0.0885	0.0642	0.0856	0.0652
	(0.274)	(0.418)	(0.399)	(0.511)
Dedicated ownership	-0.3612***	-0.3293***	-0.4026***	-0.4135***
	(0.005)	(0.009)	(0.005)	(0.003)
Firm and industry specific determinants from Table 5				
Book leverage	0.1714**	0.1833***	0.1682*	0.2005**
	(0.022)	(0.010)	(0.065)	(0.022)
Number of suppliers	0.0049*	0.0049*	0.0096***	0.0100***
	(0.055)	(0.060)	(0.001)	(0.000)
Vertical integration dummy	-0.0704*	-0.0668**	-0.0642	-0.0533
	(0.063)	(0.050)	(0.172)	(0.221)
Capital-to-labor intensity	-0.0004**	-0.0004**	-0.0010***	-0.0009***
	(0.014)	(0.019)	(0.001)	(0.003)
R&D intensity	-0.4460	-0.3332	-0.5079	-0.3952
	(0.242)	(0.369)	(0.197)	(0.296)
COGS-to-Sales	-0.1522*	-0.1332*	0.0759	0.0763
	(0.052)	(0.081)	(0.123)	(0.104)

Continued…

Table 6 (continued)

Total factor productivity	-0.0454*	-0.0528**	-0.0352	-0.0398
	(0.085)	(0.044)	(0.262)	(0.183)
Market share	0.2851**		0.1407	
	(0.024)		(0.318)	
Herfindahl index		0.4099***		0.4924***
		(0.000)		(0.000)
Unionization	0.0054***	0.0042**	0.0095***	0.0068**
	(0.008)	(0.028)	(0.008)	(0.049)
Merger intensity	-0.3389	-0.1090	1.2893***	2.0206***
	(0.198)	(0.672)	(0.003)	(0.000)
Size	0.0283**	0.0396***	0.0367**	0.0395**
	(0.047)	(0.002)	(0.041)	(0.011)
Calendar year dummies	Yes	Yes	Yes	Yes
Industry dummies	No	No	Yes	Yes
Observations	2,187	2,187	1,802	1,802

Table 7
Announcement period wealth effects for rival firms and key supplier firms of recalling firms

This table presents the announcement period wealth effects of the recall events for the rival firms and key supplier firms of recalling firms. The sample period is 2006 – 2010 and contains recalls in the food, drug, and medical device industries covered by the Food and Drug Administration (*FDA*), the Consumer Product Safety Commission (*CPSC*), and the National Highway Traffic Safety Administration (*NHTSA*). Rival firms are identified based on the three-digit SIC code of the recalling firm. Any firm on the Compustat database with the same three-digit SIC code as the recalling firm during the recall year is considered a rival firm except if it announced its own product recall during the event window. Key suppliers of the recalling firms are found from the Compustat database based on the FASB No.14 requirement for firms to report customers that account for at least 10% of sales. The rival portfolio and key supplier portfolio returns are calculated as equally weighted returns for the (-2, +2), (-5, +5), (-10, +10), and (-10, +2) trading day windows around the recall announcement date. Z statistics are used to test if the mean cumulative abnormal returns (*CAR*s) are statistically different from zero and are provided in the parentheses. % positive represents the proportion of portfolios that have positive returns. A generalized sign test is performed to test their statistical significance. N is the number of portfolios of rivals or suppliers. Panel A and Panel B provide the *CAR*s for the rival firms and key supplier firms respectively. All panels in the table report results for the overall sample of recalls, and different sub-samples such as the *FDA*, *CPSC*, and *NHTSA* respectively. ***, ** and * indicate significance at 1%, 5%, and 10% respectively.

Panel A: Announcement period abnormal returns of the rival firms

	Overall (N=806)		*FDA* (N=354)		*CPSC* (N=313)		*NHTSA* (N=139)	
Event Windows	*CAR* (%)	% Positive	*CAR* (%)	% Positive	*CAR* (%)	% Positive	*CAR* (%)	% Positive
(-2, +2)	0.00	47.41	0.09	46.61	-0.06	48.89	-0.09	46.04
	(-0.31)	(-1.30)	(0.03)	(-1.34)	(-0.91)	(-0.04)	(0.55)	(-0.93)
(-5, +5)	-0.15	45.91**	-0.04	48.87	-0.14	45.36	-0.42	39.57**
	(-1.62)	(-2.15)	(-0.83)	(-0.49)	(-1.49)	(-1.28)	(-0.28)	(-2.45)
(-10, +10)	-0.35**	45.28**	-0.12	46.61	-0.44*	48.24	-0.69	35.97***
	(-2.25)	(-2.50)	(-1.17)	(-1.34)	(-1.70)	(-0.26)	(-0.93)	(-3.31)
(-10, +2)	-0.12	46.52*	0.20	47.74	-0.31	46.96	-0.47	42.44*
	(-1.02)	(-1.80)	(0.08)	(-0.92)	(-1.36)	(-0.72)	(-0.46)	(-1.78)
(-20, +20)	-0.63***	45.53**	-0.37*	43.78**	-1.08***	46.00	-0.25	48.92
	(-2.76)	(-2.36)	(-1.73)	(-2.40)	(-3.11)	(-1.05)	(-0.81)	(-0.25)

Panel B: Announcement period abnormal returns of key supplier firms

Number	*Overall* (N=594)		*FDA* (N=260)		*CPSC* (N=198)		*NHTSA* (N=136)	
Event Windows	*CAR* (%)	% Positive	*CAR* (%)	% Positive	*CAR* (%)	% Positive	*CAR* (%)	% Positive
(-2, +2)	-0.85***	40.57***	-0.58**	42.30**	-0.82***	41.92***	-1.41***	35.29***
	(-4.89)	(-4.49)	(-2.45)	(-2.42)	(-3.11)	(-2.20)	(-3.08)	(-3.39)
(-5, +5)	-1.23***	38.72***	-0.47*	40.38***	-1.73***	37.88***	-1.96**	36.76***
	(-4.86)	(-5.39)	(-1.79)	(-3.03)	(-4.23)	(-3.33)	(-2.57)	(-3.04)
(-10, +10)	-1.85***	40.74***	-1.38**	42.69**	-1.82***	40.40***	-2.79***	37.50***
	(-5.29)	(-4.41)	(-2.47)	(-2.29)	(-4.10)	(-2.62)	(-2.65)	(-2.87)
(-10, +2)	-1.42***	39.73***	-1.25**	39.23***	-1.38***	38.38***	-1.80**	42.65*
	(-4.71)	(-4.89)	(-2.11)	(-3.41)	(-3.73)	(-3.19)	(-2.42)	(-1.67)
(-20, +20)	-1.66***	40.91***	-0.76*	43.85*	-1.40***	37.88***	-3.74***	39.71**
	(-4.68)	(-4.32)	(-1.80)	(-1.92)	(-3.53)	(-3.33)	(-3.02)	(-2.36)

Table 8
Determinants of announcement period wealth effects of recalling firms

This table presents the treatment effect estimation results for the determinants of the announcement period abnormal returns to recalling firms. In the first stage (unreported), we model the recall incidence where the dependent variable is *RecallDum*, which is set to one for firms in the recall sample and zero for control firms. Control firms are firms that belong to the same three-digit SIC industry as the recalling firm provided they did not have a recall during 2006 – 2010. In the second stage, the dependent variable is the cumulative abnormal return (*Recalling firm CAR*) measured over the (-5, +5) or (-10, +10) event window around the recall announcement date and weighted least squares estimations are followed. Recalls in the food, drug, and medical device industries covered by the Food and Drug Administration (*FDA*), the Consumer Product Safety Commission (*CPSC*), and the National Highway Traffic Safety Administration (*NHTSA*) are included in the sample. *Brand capital* measures the investment of the recalling firm in brand and calculated per the methodology in Lin, Belo, and Vitorino (*2012). Unionization* is the percentage of employees in the industry that are unionized. *KZ index* is the Kaplan and Zingales (1997) index of financial constraints. *Compensation gap* is the difference between CEO's compensation and the total compensation of the median VP. *CEO delta* is the CEO's total portfolio delta and *CEO vega* is the CEO's total portfolio vega and are based on Kini and Williams (2012). *Transient ownership* is the percentage of institutional ownership that is held by transient institutional investors. *Dedicated* (*Quasi-indexer*) *ownership* is the percentage of institutional ownership that is held by dedicated (quasi-indexing) institutional investors. *Size* is the lagged logarithm of the market value of equity. *Initial recall dummy* is an indicator variable set to 1 if the recall event is the first by the recalling firm during our sample period and set to 0 otherwise. *Inverse Mills Ratio* is calculated based on the first stage estimation of the likelihood of recall incidence. Models 1 and 2 contain estimation results when we do not include compensation and institutional ownership variables and Models 3 and 4 contain estimation results when we include compensation and institutional ownership variables. Reported *p*-values in the parentheses are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10% respectively.

Dependent variable: *Recalling firm CAR*	(1) (-5, +5)	(2) (-10, +10)	(3) (-5, +5)	(4) (-10, +10)
Brand capital	0.0010*	0.0020**	0.0012	0.0031**
	(0.088)	(0.013)	(0.202)	(0.020)
Unionization	0.0004**	0.0004	0.0009***	0.0012**
	(0.028)	(0.129)	(0.003)	(0.028)
KZ index	-0.0008**	-0.0007	-0.0007*	-0.0004
	(0.025)	(0.236)	(0.065)	(0.525)
CEO delta			0.0131**	0.0221***
			(0.021)	(0.000)
CEO vega			-0.0193**	-0.0340***
			(0.027)	(0.001)
Compensation gap			0.0082*	0.0027
			(0.059)	(0.680)
Transient ownership			-0.0829**	-0.1186*
			(0.027)	(0.090)
Quasi-indexer ownership			0.0016	-0.0119
			(0.941)	(0.742)
Dedicated ownership			-0.0161	0.0438
			(0.637)	(0.493)
Size	-0.0011	-0.0025	-0.0041	-0.0018
	(0.633)	(0.410)	(0.213)	(0.733)
Initial recall dummy	0.0079*	0.0074	0.0032	0.0034
	(0.094)	(0.248)	(0.627)	(0.675)
Inverse Mills Ratio	-0.0115**	-0.0133*	-0.0041	-0.0011
	(0.036)	(0.099)	(0.565)	(0.926)
Constant	-0.0067	-0.0017	-0.0387	-0.0221
	(0.800)	(0.964)	(0.396)	(0.776)
R-squared	0.04	0.02	0.07	0.06
Observations	758	758	379	379

Table 9
Determinants of announcement period wealth effects of industry rival firms

This table presents the weighted least squares estimation results for the determinants of the announcement period abnormal returns to rival firms. The dependent variable is the cumulative abnormal return for the rival portfolio (*Rival firms' CAR*) measured over the (-5, +5) or (-10, +10) event window around the recall announcement date. *Recalling firm CAR* is the cumulative abnormal return for the recalling firm over the (-5, +5) and (-10, +10) event window. *KZ index* is the Kaplan and Zingales (1997) index of financial constraints for the recalling firm. *Brand capital* measures the investment of the recalling firm in brand and calculated per the methodology in Lin, Belo, and Vitorino (2012). *Size* is the lagged logarithm of the market value of equity of the recalling firm. *Initial recall dummy* is an indicator variable set to 1 if the recall event is the first by the recalling firm during our sample period and set to 0 otherwise. Reported *p*-values in the parentheses are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10% respectively.

	(1)	(2)
Dependent variable: *Rival firms' CAR*	(-5, +5)	(-10, +10)
Recalling firm CAR (-5, +5)	0.0428*	
	(0.057)	
Recalling firm CAR (-10, +10)		0.0377*
		(0.069)
KZ index	0.0001	0.0003**
	(0.312)	(0.049)
Brand capital	-0.0008	-0.0010
	(0.105)	(0.160)
Initial recall dummy	0.0055*	0.0064
	(0.064)	(0.145)
Size	0.0007	0.0001
	(0.481)	(0.931)
Constant	-0.0048	0.0001
	(0.582)	(0.992)
R-squared	0.02	0.01
Observations	789	789

Table 10

Determinants of announcement period wealth effects of key suppliers

This table presents the weighted least squares estimation results for the determinants of the announcement period abnormal returns to key supplier firms. The dependent variable is the cumulative abnormal return for the supplier portfolio (*Supplier firms' CAR*) measured over the (-5, +5) or (-10, +10) event window around the recall announcement date. *Recalling firm CAR* is the cumulative abnormal return for the recalling firm over the (-5, +5) and (-10, +10) event window. *Brand capital* measures the investment of the recalling firm in brand and calculated per the methodology in Lin, Belo, Vitorino (2012). *KZ index* is the Kaplan and Zingales (1997) index of financial constraints for the recalling firm. *Supplier R&D intensity* is the lagged supplier portfolio research & development intensity. *Size* is the lagged logarithm of the market value of equity of the recalling firm. *Initial recall dummy* is an indicator variable set to 1 if the recall event is the first by the recalling firm during our sample period and set to 0 otherwise. Reported *p*-values in the parentheses are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10% respectively.

	(1)	(2)	(3)	(4)
Dependent variable: *Supplier firms' CAR*	(-5, +5)	(-10, +10)	(-5, +5)	(-10, +10)
Recalling firm CAR (-5, +5)	0.1213***		0.1214***	
	(0.003)		(0.002)	
Recalling firm CAR (-10, +10)		0.1599***		0.1638***
		(0.000)		(0.000)
Brand capital	0.0003	0.0012		
	(0.529)	(0.183)		
KZ index	0.0004	0.0001		
	(0.130)	(0.830)		
Supplier R&D intensity			-0.0424**	-0.0570**
			(0.030)	(0.047)
Initial recall dummy	0.0063	0.0057	0.0061	0.0047
	(0.171)	(0.515)	(0.189)	(0.601)
Size	-0.0020	-0.0033	-0.0020	-0.0023
	(0.260)	(0.241)	(0.217)	(0.387)
Constant	0.0114	0.0160	0.0148	0.0170
	(0.558)	(0.608)	(0.391)	(0.563)
R-squared	0.04	0.05	0.04	0.05
Observations	576	576	567	567

Table 11

Corporate policies around recall events

This table presents the results for change in corporate policies around recall events during our sample period of 2006 – 2010. The table reports recalls in the food, drug, and medical device industries. Control firms are firms that belong to the same three-digit SIC industry as the recalling firm provided they did not have a recall during 2006 – 2010. Panel A reports results for the changes in corporate policy and measured as the difference between the policy variable for year *t+1* and the value of the performance variable for year *t-1* where year *t* is the recall announcement year. Panel B reports results for the changes in corporate policy and measured as the difference between the average of the policy variable over years *t+1* and *t+2* and the average of the policy variable over years *t-1* and *t-2*, where year *t* is the recall announcement year. In the results based on propensity score matching implemented through PSMATCH2 command of STATA, the column Treated (Control) reports the change in the performance variable for the treated (control) group. The column *Difference* represents the average treatment effect of the treated (*ATT*). In the results based on Abadie and Imbens matching implemented through NNMATCH command of STATA, the column *Difference* represents the average treatment effect of the treated group. The column *Coef* reports the coefficient on the recall incidence dummy in a regression of the change in policy variable on the recall incidence dummy, calendar year dummies, and industry dummies. The T-stat and Z-stat measure the statistical significance of *ATT*. ***, ** and * indicate significance at 1%, 5%, and 10% respectively.

Panel A: Corporate policy changes measured from t-1to t+1 where year t is recall announcement year

Variable	Treated	Control	*Difference*	T-stat	*Difference*	Z-stat	*Coef*	T-stat
	PSMATCH2				NNMATCH		OLS	
Change in R&D intensity	-0.0010	-0.0005	-0.0006	-0.07	0.0029	0.42	-0.0016	-0.23
Change in capital expenditure intensity	-0.0090	-0.0067	-0.0022	-0.64	-0.0065	-1.51	-0.0023	-0.81
Change in advertising intensity	0.0015	-0.0012	0.0027**	2.11	0.0031*	1.82	0.0027**	2.49
Change in SG&A	0.0156	-0.0267	0.0423**	2.59	0.0230	1.53	0.0314***	2.86
Change in operating expenses	0.0135	-0.0902	0.1037	1.66	0.0332	0.78	0.3663***	3.47
Change in AR/Sales	0.0018	0.0015	0.0003	0.04	0.0017	0.22	0.0006	0.09
Change in AP/COGS	0.0220	0.0105	0.0114	0.70	0.0239	0.86	0.0204	1.48
Change in Inv/COGS	-0.0082	0.0113	-0.0195	-1.26	0.0161	0.82	-0.0060	-0.45
Sales growth	0.0542	0.1688	-0.1145**	-2.63	-0.1191**	-2.25	-0.2137***	-5.30

Panel B: Corporate policy changes measured as averages of years t-1and t-2 compared to years t+1 and t+2

Variable	Treated	Control	*Difference*	T-stat	*Difference*	Z-stat	*Coef*	T-stat
	PSMATCH2				NNMATCH		OLS	
Change in R&D intensity	0.0011	0.0004	0.0006	0.10	0.0092	1.72	0.0001	0.01
Change in capital expenditure intensity	-0.0103	-0.0057	-0.0046	-1.54	-0.0052	-1.36	-0.0014	-0.54
Change in advertising intensity	0.0022	-0.0026	0.0048***	3.00	0.0046**	2.49	0.0038***	2.69
Change in SG&A	0.0063	-0.0326	0.0389*	1.85	0.0250	1.41	0.0491***	3.78
Change in operating expenses	0.0243	-0.1363	0.1606	1.16	0.0703	1.40	0.7481***	3.82
Change in AR/Sales	0.0108	0.0018	0.0090	1.08	0.0113	1.50	0.0136*	1.71
Change in AP/COGS	0.0210	0.0040	0.0170	1.16	0.0219	0.80	0.0234**	2.05
Change in Inv/COGS	-0.0155	0.0122	-0.0277*	-1.78	0.0256	1.24	-0.0052	-0.37
Sales growth	0.0905	0.2867	-0.1962***	-3.41	-0.2071***	-3.11	-0.3453***	-5.60