Relative leverage and valuation consequences of product recalls along the supply chain[+]

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Abstract

We document a previously overlooked cost of product recalls which stems from a potential vulnerability in the competitive position of the recalling firm. Drawing upon theories that examine the interplay between firm financing decisions and product market competition, we argue that the costs of a recall are exacerbated when recalling firms are more financially constrained by higher *relative leverage*, that is, higher debt ratios compared to their industry rivals. Analyzing the wealth consequences of recalls, we find that higher relative leverage negatively affects the recalling firm and its dependent suppliers, but benefits industry rivals. The negative impact of relative leverage on the recalling firm's value is confined to economic environments where it faces greater product market threats, indicating that competitive effects impose additional costs for recalling firms. We find that there is an adverse market share consequence to product recalls for firms with high relative leverage, but only in settings where the firms face greater product market threats – reinforcing the finding that these costs arise from strategic product market effects. Finally, once we control for these strategic effects, we find that the wealth effects of both rivals and dependent suppliers are positively related to the recalling firm's wealth effects, thereby indicating that recalls have both horizontal and vertical contagion effects. Overall, our main findings indicate that product recalls render firms more vulnerable to strategic responses by rivals when the recalling firms are relatively more levered and in environments where they face greater product market threats.

Keywords: Product recalls, relative leverage, wealth effects, product market interactions, contagion.
JEL Classification: G30, G32, G38, L10, L15

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1. Introduction

The prior literature has broadly examined the impact of changes in product quality on firm valuation and operating performance. For example, studies have analyzed the impact of positive indicators of quality changes such as TQM implementation and other process management initiatives on firms' sales, costs, profits, productivity, and other operating performance metrics (Ittner and Larcker, 1996 and 1997; Hendricks and Singhal, 1997; Easton and Jarrell, 1998; Iyer, Saranga, and Seshadri, 2013; and Zhang and Xia, 2013). Prior studies have also examined both announcement period and long-term stock returns following quality awards from independent agencies (Hendricks and Singhal, 1996 and 2001) and long-term operating performance following the implementation of quality management systems standards (Corbett, Montes-Sancho, and Kirsch, 2005). Studies on negative indicators of quality have often focused on product recalls, as they represent distinct quality failure events in the life of a firm (e.g., Jarrell and Peltzman, 1985; Thirumalai and Sinha, 2011; and Shah, Ball, and Netessine, 2017). In a product recall, a firm withdraws its products from the market because of a significant quality failure such as the presence of a safety hazard or one where the product is unable to perform its fundamental function.[1] Federal law requires that firms suspend selling the product as soon as a safety defect is detected, and report the issue to the agency that regulates the product.[2]

Prior studies analyzing product recalls (e.g., Jarrell and Peltzman, 1985; Davidson and Worrell, 1992; Dranove and Olsen, 1994; Barber and Darrough, 1996; and Cheah, Chan, and Chieng, 2007) show that recalls impose substantial direct costs associated with repairing, and sometimes replacing, the

[1] Some recent product recalls include certain Volkswagen vehicle models due to violation of emission control standards, Samsung Note S7 mobile devices because of battery defects, and Lotus heart valve devices due to problems at the time of implantation. Other well-known recalls include automobile recalls by Toyota 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 recalls due to E. Coli and Salmonella infections such as ConAgra's recall of Peter Pan peanut butter and Banquet potpies, and toy recalls due to unsafe lead content (e.g., recalls of Barbie accessories by Mattel, and Bongo Band toys by Fisher-Price).
[2] The relevant regulating agencies are the Consumer Product Safety Commission (*CPSC*), Food and Drug Administration (*FDA*), and the National Highway Traffic Safety Administration (*NHTSA*). The agencies are empowered by various provisions in the law such as the *Consumer Product Safety Act* and the *Federal, Food, Drug, and Cosmetic Act,* which require that firms report safety issues immediately. The *NHTSA* requires that firms report quality defects within five days after they determine the presence of a safety defect.

malfunctioning product and are often a major adverse shock for the recalling firm with significant negative wealth effects. More importantly, these studies also show that the overall costs of a recall are substantially more than just the direct costs in that they include reputational damage, penalties imposed by regulating agencies, and consequences of lawsuits brought on by the damaged parties.[3] In a detailed study of the Volkswagen (VW) emissions scandal and subsequent product recall, Jacobs and Singhal (2020) encourage a larger scale study of the wealth effects of such crises on firms' "industrial ecosystem" and argue that it "could lead to useful comparisons and generalizations." In this paper, we follow that advice and analyze a large sample of product recalls in a wide cross-section of industries. We empirically analyze a potentially important, but largely overlooked, cost of recalls – one which arises when product recalling firms compete with financially stronger rivals. In this setting, we analyze the valuation consequences of recalls on recalling firms, their industry rivals, and their dependent suppliers, and the variation in these wealth effects due to the recalling firm's relative financial position vis-à-vis industry rivals and its product market environment. We also explore whether there are any contagion effects on industry rivals and dependent suppliers from product recalls.

As we elaborate below, a rich theoretical literature argues that strategic effects associated with having higher debt levels relative to industry rival firms (henceforth "relative leverage") is likely to be particularly important when a firm faces an adverse shock. Therefore, we argue that when there is a negative shock such as a product recall, high relative leverage will amplify the risk of predation by rivals; that is, rivals will exploit the recalling firm's heightened vulnerability by taking strategic actions that will further dilute market share and decrease shareholder value of the recalling firm. To examine this cost of recalls, we analyze the role of relative leverage in explaining the value consequences of recalls for not only the recalling firms, but also for their industry rivals and dependent suppliers, i.e., firms that supply a significant proportion of their output to recalling firms. To understand whether any part of the value consequences is due to strategic effects in the product market, we also analyze the impact of the nature of the product market

[3] Dawar and Pillutla (2000) explore the impact of recalls on the brand equity of firms, and Lee, Hutton, and Shu (2015) examine the stock price impact of recalling firms' efforts to manage the recall crisis through interactive social media.

environment on the link between relative financial strength and the product recall's valuation and market share consequences.

There is reason to believe that high relative leverage impacts the strategic behavior of firms and their rivals and, consequently, has important strategic product market effects that are exacerbated by the product recalls. Poitevin (1989), Bolton and Scharfstein (1990), Faure-Grimaud (2000) present theoretical models in which high leverage places firms at a competitive disadvantage in the product markets. Povel and Raith (2004) additionally shows that constrained firms have a cost disadvantage that makes them weaker competitors. Consistent with their arguments, Chevalier (1995a, 1995b) and Lerner (1995) empirically show that firms with high leverage are at a significant product market disadvantage in the supermarket and disk-drive industries, respectively, compared to their less levered rivals. In addition, Chevalier (1995b) and Phillips (1995) find evidence consistent with predation following highly levered transactions, but only when the rivals are themselves not highly levered, i.e., only when the rivals are financially able to take advantage of the competitor's financial weakness. In a similar vein, Campello (2003) shows that the sales growth of highly levered firms is more adversely impacted during recessions compared to that of their relatively less levered rivals.

These findings suggest that there are adverse strategic effects associated with high relative leverage and they are especially likely to be important during adverse shocks such as a product recall, thereby suggesting that strategic effects can constitute an important cost of recalls. Product recalls provide a setting that is particularly conducive to study the strategic effects of relative leverage because recalls are well-defined quality failure events which can be traced back to a specific announcement date, with material and measurable impact (via the stock market reaction) for the recalling firm and its product market rivals.

These features of product recalls enable us to study the variation in wealth effects of the recalling firms, their industry rivals, and dependent suppliers based on the relative leverage of the recalling firms and the product market environment in which the recalling firms operate. Specifically, we test the predictions derived from the literature that a weaker financial position relative to industry rivals is likely to make the firm a weaker competitor in the product market. High relative leverage for the recalling firm not only captures the potential financial difficulties faced by the firm in its own efforts to recover from the recall, but also captures the ability of its rivals to take advantage of the recalling firm's crisis in the product market.

Our initial analysis examines the direct impact of the financial condition of recalling firms relative to their product market rivals on the announcement-period cumulative abnormal returns (hereafter "wealth effects") of the recalling firms, rival firms, and dependent suppliers. To examine whether the link between the relative financial strengths of the recalling firms and their rivals and the wealth effects of recalls is due to the strategic role of leverage, we repeat the analyses by separating the recall events into two subsamples based on whether the recalling firm has high or low product market risk. Prior studies on capital structure and product market interaction indicate that industry rivals undertake strategic actions when the product market structure enables expropriation of value from competitors; that is, when strategic actions are likely to be more effective. If high relative leverage does indeed place a recalling firm at a disadvantage (and the rivals at an advantage), then the link between relative leverage and value consequences will be more pronounced in the subsample of firms that face higher product market risk.

To perform the empirical analysis in the paper, we collect data over the 2003–2013 period on product recalls by publicly traded firms. We obtain data on consumer product recalls, food, drug, and medical equipment recalls, and automobile and related products recalls from the relevant regulatory agencies. In order to obtain reliable recall announcement dates for our analysis of wealth effects, we additionally require that the news of the recall should have appeared in some publication that is included in the Factiva database. This results in a dataset of 1,592 recalls included in the regulating agencies' filings and with reliable announcement dates in the press. Other details of the data collection procedure are elaborated in Section 3.1.

Our examination of the valuation consequences of recalls indicates that recalls result in significant value destruction for the shareholders of the recalling firms. Specifically, we find that recalls in our sample are associated with average abnormal returns of –1.08% for the recalling firms over a (–5, +5) day window around the announcement date. The magnitude of these returns may appear modest compared to some large negative returns documented for certain major and infamous recalls in the news, such as the Volkswagen emission scandal and recall (Jacobs and Singhal, 2020). However, it should be noted our sample contains a wide cross-section of firms of differing size, industry, and value, and includes both major and minor recalls.[4] But more saliently, in dollar terms, the abnormal returns we report translates into an average abnormal value loss of $325 million to recalling firms.

We examine the drivers of the heterogeneity in recalling firms' stock price reaction around the announcement of recalls. After using a variety of econometric techniques to empirically account for the fact that the recall event may be partially anticipated by the market, we find that when a firm has relatively higher leverage than its industry rivals, the stock market expects the recalling firm to suffer greater losses. This may be due to predatory strategic actions expected to be taken in response to the recall by its financially less-constrained industry rivals. However, since it is possible that financially weaker firms or those with poor operating efficiency may also be ones with a higher relative leverage, the wealth effect finding may simply be the consequence of these other factors and not due to any expected strategic product market actions by industry rivals. We undertake several steps to empirically address this concern. As a first step, in the regressions explaining the stock price reaction to recalls, we directly control for the prior financial condition and operating efficiency of the firm, and continue to find a negative impact of relative leverage on the stock price reaction to recall announcements. In addition, in our analysis of rival firm stock price reactions to the product recall, we find that when a recalling firm is relatively more levered than its industry rivals, the rivals benefit more from the recall. This bolsters the argument that there are more predation-related benefits to rivals when they are dealing with a financially vulnerable recalling firm as predicted in Poitevin (1989), Bolton and Scharfstein (1990), Faure-Grimaud (2000), and Povel and Raith (2004).

To further sharpen the identification of strategic product market effects of recalls, we conduct several additional tests. First, we examine whether the impact of relative leverage on the wealth effects of product recalls on recalling firms and their industry rival firms differs across strategic and non-strategic product market environments. If there are strategic product market effects, that is, if recalling firms with

[4] As in our sample, Lee, Hutton, and Shu (2015) focus on both major and minor recalls but restrict their sample to only CPSC recalls. They document abnormal returns that are slightly smaller in magnitude than those reported here.

higher relative leverage are exposed to incremental predation-risk following the recall shock, then we would expect the relation between relative leverage and stock price reaction to recalls to be more pronounced when the firm faces greater competitive threats in its product markets. Based on the product market risk ("*fluidity*") metric in Hoberg, Phillips, and Prabhala (2014), we posit that firms that face high product market risk have high potential for strategic product market interactions. Our results show that higher relative leverage for recalling firms leads to more negative abnormal returns for the firms and more positive abnormal returns for their rivals, but only in the strategic environment subsample; that is, only in environments where rivals' predation-related benefits are likely to be high. Once again, these results persist after controlling for prior financial condition and operating efficiency of the firm.

Second, we examine the impact of relative leverage on the change in the market share of recalling firms. In these tests, we implement a research design that explicitly considers the possibility that recalls do not have any product market competition related costs. That is, the impact of high relative leverage on the subsequent drop in market share would have happened anyway irrespective of the recall shock, and so the marginal impact is the same for both recalling and non-recalling firms. To measure the incremental impact of recall events on the strategic product market effects of relative leverage, we include all firms – both recalling and non-recalling firms – in a large panel dataset and examine the impact of recall frequency in year t (a metric that is zero for non-recalling firms), the relative leverage of a firm, and the interaction-term between recall frequency and relative leverage on the change in market share (t-1, t+1). Consistent with recalls having product market competition related costs, we find that the coefficient on the interaction term is significantly negative, signifying that the adverse consequence of higher frequency of recalls on the change in market share worsens with higher relative leverage. Third, consistent with our findings on the valuation effects, we find that the adverse impact on the change in market share due to high relative leverage in recalling firms is confined to economic environments where firms face higher product market threats. This result again suggests that recalling firms with high relative leverage that also face significant product market competition are especially susceptible to strategic responses by industry rivals. All the above results hold either with or without the inclusion of a variety of proxies that control for the financial condition and operating efficiency of the firm.

Additionally, firms' raw leverage level is significantly negatively related to the wealth effects and change in market share for both the high and low product market risk subsamples, which suggests that raw leverage effects are unrelated to product market competition. Viewed together, these results show that relative leverage and raw leverage levels capture two distinct ways that product recalls have valuation and real consequences, with relative leverage capturing the effect of potential strategic actions by rival firms and a firm's raw leverage level purely reflecting the effect of the recalling firm's financial condition.

As an independent indication of the importance of relative leverage for the wealth consequences of recalls, we find evidence that dependent suppliers are worse off when the relative leverage of the recalling firm is large – highlighting the negative consequences of relying on a customer-firm that is potentially at a weaker competitive position. This finding highlights an important aspect of operational risk for suppliers (Seshadri and Subrahmanyam, 2005), one which arises from the quality failures of their large customer-firms. In addition, our results reinforce, in a broad cross-section, the finding in Jacobs and Singhal (2020) that the tier-1 suppliers of VW lost significant value following its emissions scandal and subsequent recall. In fact, we find that a more negative stock price reaction to the recalling firm results in a more negative price reaction for the dependent suppliers, highlighting the contagion effects for upstream firms.

Finally, once we control for the relative leverage of the recalling firm, i.e., when we isolate and focus only on the non-strategic effects, we find that the rival firms' wealth effects are positively related to the recalling firm's wealth effects. Thus, bad news for the recalling firm is viewed in the market as bad news for the rivals too – alluding to contagion effects from the recall. Contagion effects of recalls may arise due to post-recall negative perceptions about the whole product category (Freedman, Kearney, and Lederman, 2012) or due to any costly regulation that affects the entire industry (Dranove and Olsen, 1994). Dranove and Olsen (1994), for example, document industry-wide negative effects for pharmaceutical drug recalls when the recalls are associated with contemporary changes in industry regulations. Taken together, the rival and dependent supplier wealth effects indicate that product recalls have both horizontal (industry-wide) and vertical (supplier) contagion effects.

Our study contributes to the product quality, product markets, and supply chain literatures. First, unlike any of the prior research on recalls, we focus on the role of relative leverage on the wealth effects of recalls and present evidence that the relative financial position of a firm plays an incremental and critical role in determining the costs faced by recalling firms. The availability of product recalls data across multiple industries enables us to conduct a nuanced analysis of the relation between relative financial condition of firms and the value consequences of recalls associated with strategic product market competition. Our analysis contributes to studies that examine the costs of recalls (e.g., Jarrell and Peltzman, 1985; Davidson and Worrell, 1992; Dranove and Olsen, 1994; and Cheah, Chan, and Chieng, 2007). Specifically, our results suggest that costs of recalls not only include previously documented costs such as repair/replacement, legal, and reputational costs, but also costs associated with the impact of the recall shock on the competitive position of the firm. Our findings also contribute to the literature on strategic effects of debt and offer independent evidence of the adverse product market effects of high relative leverage. Second, we also add to the literature on the performance and value implications of quality enhancing initiatives undertaken by firms (e.g., Hendricks and Singhal, 1996 and 2001; Corbett, Montes-Sancho, and Kirsch, 2005; Iyer, Saranga, and Seshadri, 2013; and Zhang and Xia, 2013) by studying the flip side of the quality-coin and analyzing a key component of the valuation consequence of quality failures.

Third, although there are prior papers that have studied the wealth effects of product recalls, most are confined to recalls in specific industries like automobiles and pharmaceuticals. In contrast, we analyze recalls of all types of products, spread across 101 (37) different three-digit (two-digit) SIC code industries. This allows for more generalizable inferences about the wealth effects of recalls for recalling firms, their industry rivals, and their dependent suppliers. For instance, we find that there are significant negative effects on the dependent suppliers of recalling firms, and they are worse when the strategic vulnerability of the recalling firms is greater. These findings regarding dependent suppliers offer additional corroboration of the adverse strategic effects of product recalls. Further, once we control for strategic effects, we find that there are horizontal and vertical contagion effects associated with recalls even in a broad cross-section of product recalls. Such an analysis enables us to extend and generalize the results in Jacobs and Singhal (2020) on the impact of the VW emissions scandal and subsequent recall on the firm's industrial ecosystem.

The rest of the paper is organized as follows. Section 2 describes our hypotheses regarding the wealth effects around recalls for the recalling firms, their rivals, and dependent suppliers. We also highlight the expected relation between relative leverage and the wealth effects of recalls in different product market environments. In Section 3 we describe our data collection procedure and provide summary statistics on the characteristics of recalling firms. Section 4 contains our empirical analysis of the link between relative leverage of the recalling firm and the value consequences of the recall for recalling firms, their rivals, and dependent suppliers. In Section 5, we analyze the impact of the product market environment on the relation between relative leverage and the wealth effects of recalls on recalling firms and rivals. In Section 6, we focus on the real effects of product recalls and the relative financial condition of a firm by examining changes in market share for both recalling and non-recalling firms. Section 7 concludes the paper.

2. Hypotheses development: Relative leverage, product market environment, and the wealth effects of product recalls

2.1. Wealth effects of recalling firms, industry rival firms, and dependent supplier firms

Product recalls are costly events in the life of a firm involving both significant direct and indirect costs. The direct costs are those that arise from investigating the product failure and conducting the actual recall (which can include either repairing or replacing the defective product). However, prior literature indicates that the indirect costs of recalls may be much higher than the direct costs (see, e.g., Jarrell and Peltzman, 1985; Davidson and Worrell, 1992; Dranove and Olsen, 1994; and Cheah, Chan, and Chieng, 2007). In addition to the reputational damage to the firm, it may also include expected damages from any product liability lawsuits, and costs associated with future changes to the design, sourcing, manufacturing, and packaging processes. If there are any regulatory violations, the costs may further include any anticipated penalties. Therefore, we expect the stock price reaction, as captured by the cumulative announcement-period abnormal returns (*Recalling firm CAR*) around product recalls, to be significantly negative for the recalling firms. Since, by definition, dependent suppliers of recalling firms rely on the recalling firms for a large fraction of their business, a disruption in the production process of the recalling firm can cause significant damage to the sales of the suppliers (Jacobs and Singhal, 2020). And, a more negative wealth effect for the recalling firm would suggest that the recalling firm's troubles are more significant. Therefore, we expect that when a firm announces a product recall, its supplier firms will suffer negative abnormal returns as well, and these returns will be more negative when the recalling firm's abnormal returns are more negative.

Product market rivals of recalling firms are exposed to two countervailing effects. The first is the *competitive* effect where product recalls have a negative effect on customer perception about the recalling company's product quality and this may shift demand to the firm's rivals. It is possible that industry rivals can exploit the crisis in the recalling firm to their own advantage via predatory pricing, advertising, and investment strategies that enable the rival to extract market share away from the recalling firm, which is similar to the "substitution effect" in Ni, Flynn, and Jacobs (2014). This effect should result in positive announcement-period abnormal returns for the rivals (*Rival firms' CAR*).

The second effect is the *contagion* effect. If the entire reason for recall is not just specific to the firm, but has an industry-wide component that may also apply to rival firms' products, then there would be a contagion effect associated with the product recall. This effect would suggest that rival firms will also experience negative announcement-period abnormal returns. Contagion effects of recalls may be in the form of additional direct costs such as packaging restrictions for the whole industry (e.g., the Tylenol recall), or negative perceptions about the whole product category (e.g., SUVs and rollover risk), or fear of other costly miscellaneous regulations that affect the industry as a whole (e.g., toy recalls due to unsafe lead content, battery-related fire hazard in mobile devices, etc.). Dranove and Olsen (1994) find that there is an industry-wide negative stock price effect for drug recalls when there is an associated change in regulations for the industry. For example, 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 nine-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 (Dowdell, Govindaraj, and Jain, 1992). Similarly, Crafton, Hoffer, and Reilly (1981) and Reilly and Hoffer (1983) show in their study of automobile recalls that industry rivals suffer a decrease in sales if they manufacture similar types of automobiles as the recalling firm. So, the contagion effect should result in a negative *Rival firms' CAR*.

Since a typical recall event has both competitive benefits and contagion costs to rivals, the observed wealth effect of rivals in a recall is the net consequence of the competitive and contagion effects combined. So, we do not have an *ex ante* prediction about the sign of the announcement-period abnormal returns to rivals. The sign will depend upon whether the competitive or contagion effects dominate. Also, in a regression where *Rival firms' CAR* is the dependent variable and the *Recalling firm CAR* is the independent variable, *Recalling firm CAR* may have a positive or a negative coefficient depending on which of the two effects dominates. We expect the coefficient will be negative if the competitive effects are dominant, while it will be positive if the contagion effects are dominant.

2.2. Relative leverage and the wealth effects of recalling firms, industry rivals, and dependent suppliers

We expect financial constraints to hinder a firm's recovery following a product recall, especially if the firm's product market rivals are relatively less levered. This prediction derives from the strategic consequences of high relative leverage. Fudenberg and Tirole (1986), Poitevin (1989), Bolton and Scharfstein (1990), Faure-Grimaud (2000), and Povel and Raith (2004) present theoretical models in which highly levered firms operating under imperfect competition are at a disadvantage in their product markets. Consistent with this view, Grullon, Kanatas, and Kumar (2006) show that firms that are relatively highly levered are unable to advertise aggressively and are more vulnerable to product market competition. Using scanner data of actual product prices, Chevalier (1995a, 1995b) finds that following LBOs in the supermarket industry, non-LBO rivals lower their product prices to prey on the highly levered firms. Subsequently, since the LBO supermarkets are unable to sustain a price war because of their financial condition, they exit the market. She also finds that non-LBO rivals experience a positive stock price reaction to the announcement of LBOs, and that there is more entry into the industry. In a similar vein, Lerner (1995) who analyzes the disk-drive industry, finds that when undiversified and financially constrained firms launch a product, they are met with aggressive price reductions by their less constrained rivals, pushing the relatively highly levered firms closer to distress. In a similar vein, Campello (2003) shows that sales growth of highly levered firms is more adversely impacted during recessions compared to their relatively less levered rivals.

An implication of these findings in our context is that when a firm is faced with a product market crisis such as a product recall, it is likely that the firm's ability to deal with the crisis is a function of its leverage. Additionally, if there are strategic effects associated with relative leverage as the prior evidence suggests, such effects are especially likely to be important during material adverse events such as a product recall. Therefore, the above findings suggest that we should expect recalling firms with high relative leverage to be targets of predation activities by rival firms and consequently suffer more following the recall. And, since product market rivals expect more predation-related gains when the recalling firms have relatively higher leverage, we expect rival firms to benefit more under those conditions. Therefore, the view that higher relative leverage results in greater vulnerability in the product markets for recalling firms leads to the following hypotheses:

Hypothesis 1: Recalling firm CAR will be negatively related to the relative leverage of the firm.

Hypothesis 2: Rival firms' CAR will be positively related to the relative leverage of the recalling firm.

Additionally, for firms that are highly levered relative to industry rivals, if there are incremental adverse market share consequences when undergoing product recalls due to strategic product market effects, then it leads to the following hypothesis:

Hypothesis 3: The change in market share for firms (from year t–1 to year t+1) will be negatively related to the interaction variable, relative leverage × recall frequency, where recall frequency is the number of recalls the firm undergoes in year t.

Hypothesis 3 predicts that the coefficient on the interaction term will be negative; that is, the strategic product market effects will be more pronounced for firms that have a higher frequency of recalls and are highly levered relative to rivals as the rivals will be able to capitalize on the relatively weaker firm's travails.

Therefore, this hypothesis is a direct test of whether there are any strategic product market competition related consequences to recalls.

As dependent suppliers of the recalling firms are those suppliers who rely on the recalling firm for a substantial portion of their business, we expect the recalling firm's troubles to spillover to the suppliers as well. A case in point is the VW emissions scandal and subsequent recall where Jacobs and Singhal (2020) document that tier-1 suppliers of VW lost significant amounts of value as the crisis evolved. In our setting, this is especially true if the recalling firms have high relative leverage, thereby making it more likely that rivals will steal market share and profitability away from the recalling firm.

<u>Hypothesis 4</u>*: Supplier firms' CAR will be negatively related to relative leverage of the recalling firm.*

The view that high leverage makes firms weaker competitors in product markets is not unanimous in the theoretical literature. Brander and Lewis (1986) present a model where firms set output quantities to maximize shareholder value. They show that when firms operate under demand uncertainty, shareholders will be unconcerned about profits when the firm is in financial distress since shareholders have limited liability. Therefore, the shareholder value maximizing output for the levered firm is higher than that of the unlevered firm, allowing the levered firm to commit to an aggressive output level. Maksimovic (1988) arrives at the same conclusion that leverage makes firms more aggressive, albeit through a different mechanism. In a repeated game framework with tacit collusion between firms, he argues that collusion – to maintain an accommodating posture in the product market – is less sustainable if shareholders expect to gain less from it. As leverage increases, so does default likelihood, and given the limited liability of the shareholders their benefits from collusion decreases as well. Thus, increased leverage makes firms deviate from collusion and, therefore, more aggressive in the product market. If, as these latter models suggest, leverage makes firms more aggressive and is an advantage in product markets, then our empirical predictions in Hypotheses 1–4 above will all be reversed. That is, the *Recalling firm CAR* and *Supplier firms' CAR* will be positively related, and *Rival firms' CAR* negatively related, to the relative leverage of the recalling firm. Additionally, market share change will be *positively* related to the interaction variable, *relative leverage × recall frequency*, where *recall frequency* is the number of recalls a firm undergoes in year *t*.

2.3. The product market environment and the wealth effects of recalls

If strategic effects are present, we also expect the nature of the product market in which the recalling firms operate to play a significant role in the costs faced by them and hence the price reaction to the recalls. Theoretical models on the product market impact of debt financing all derive their predictions under the assumption that firms operate in product markets where strategic effects are material. Therefore, we expect relative leverage of recalling firms to be a salient factor in influencing recalling firm and rival wealth effects but mainly in product market environments where the strategic effects of debt are likely to be discernable.

Hoberg, Phillips, and Prabhala (2014) use textual descriptions of products to measure changes undertaken by rivals in their products in response to a firm's products, to develop a novel metric they term "product market fluidity" to capture the product market risk or competitive threats faced by a firm. A higher value for the product market fluidity measure will then be indicative of greater product market risk exposure for a firm. The strategic impact of debt is, therefore, likely to be stronger for recalling firms facing greater product market threats. Thus, if high relative leverage makes a firm a weaker competitor, and if it is indeed the competitive interaction in the product market which renders recalls costlier for the relatively highly levered firms, then the following hypotheses obtain:

> <u>Hypothesis 5</u>*: When industries are sorted based on product market fluidity, the relative leverage of recalling firms will be significantly negatively (positively) related to Recalling firm CAR (Rival firms' CAR), mainly for firms in the high product market fluidity subsample.*
>
> <u>Hypothesis 6</u>*: When firms are sorted based on product market fluidity, the change in market share for firms (from year t–1 to year t+1) will be negatively related to the interaction variable, relative leverage × recall frequency, where recall frequency is the number of recalls a firm undergoes in year t, mainly for firms in the high product market fluidity subsample.*

If, on the other hand, high relative leverage makes firms stronger competitors, then high relative leverage is an advantage when there is more room for competitive interaction in the product market, and Hypotheses

5 and 6 will reverse, and we would have the opposite predictions. That is, the relative leverage of recalling firms will be significantly positively (negatively) related to *Recalling firm CAR* (*Rival firms' CAR*) for firms with high product market fluidity. Similarly, *relative leverage* × *recall frequency* will be significantly positively related to the change in market share for firms in the high product market fluidity subsample.

3. Data sources and sample characteristics

3.1. Sample selection

Our dataset on product recalls is collected from the websites of Food and Drug Administration (*FDA*), Consumer Product and Safety Commission (*CPSC*), and National Highway Traffic Safety Administration (*NHTSA*), the three primary regulators that oversee product quality and safety in the U.S. Our dataset contains recalls announced over the period 2003–2013.[5] A summary of our data collection procedure for product recalls is provided below. *FDA's* weekly enforcement reports is our primary source for recalls involving food, drugs, and medical equipment.[6] Recalls of all types of consumer products ranging from household appliances to nursery products and children's toys are collected from the *CPSC*. Finally, recalls of automobiles and related products are collected from the *NHTSA*. Our dataset includes the date of the recall, broad specifications of the recalled product, identity of the firm producing the product, the nature of the quality or safety defect, and the number of affected units. Further, we impose two additional criteria on recalling firms to be in our sample: (i) the firm must be publicly traded because we need stock price and other financial information in our analysis and (ii) the recall announcement must be covered by at least one of the publications or information sources in Factiva.[7]

Table 1 contains summary information about our sample. Our dataset contains 1,592 recalls, of which 611 are consumer products recalls, 437 are food, drug, and medical equipment recalls, and 544 are

[5] Earlier versions of this paper were circulated under the titles "Relative financial leverage, wealth effects of product quality failures, and product market effects" and "Financial leverage, product quality failures, and product market effects: Evidence from product recalls." In these versions, the recall sample spanned a shorter time period (2006-2010).
[6] Our sample of FDA recalls begins in 2004 as data prior to that year was unavailable on the FDA recalls database.
[7] We follow the procedure described in Kini, Shenoy, and Subramaniam (2017) to match the names of firms in the recalls database with the names of firms in standard financial databases like Compustat and CRSP because the recalls filings with these regulatory agencies do not contain any other common identifier with these databases.

automobiles and related products recalls. Except for 2003, the total number of recalls is roughly evenly spread across the years although there are some clusters within each category in certain years. Our data on recalls includes a broad category of products in more than 101 three-digit SIC industries. Table 2 shows the industry break-up of the sample using two-digit SIC codes (37 different industry groups). In our sample, Transportation Equipment (590) Chemical and Allied Products (178), and Food and Kindred Products (117) had the largest numbers of recalls.[8] Industries such as Textile Mill Products, Primary Metal Industries, Oil and Gas Extraction, Petroleum Refining and Related Products, and Paper and Allied Products had nearly no recalls. Also, service industries such as Transportation Services, Business Services, and Health Services are associated with very few recalls.

3.2. Descriptive statistics on recalling firms

Table 3 presents descriptive statistics on the recalling firms. Apart from the "relative leverage" variables, all the other variables described in the table are the same as those used by Kini, Shenoy, and Subramaniam (2017) to explain the propensity for a product failure. The detailed definitions of these variables are contained in the Appendix. The variables include measures of the financial condition of the firm computed using the book and market value of debt (*Book leverage* and *Market leverage*, respectively). The key variables used in our analysis are, however, measures of relative leverage (*Firm-to-industry book leverage* or *Firm-to-industry market leverage*). These variables are computed as the ratio of the leverage measure of the recalling firm to the leverage measure of the recalling firm's industry rivals that are in the same three-digit SIC code.[9] In addition, the table also includes descriptive statistics on: *Cash flow shock* – the three-year change in the free cash flows of the firm measured as a percentage of the firm's total asset,, *Herfindahl index* – the sales-based metric of competition in the recalling firm's three-digit SIC industry, *Unionization* – the fraction of unionized employees in the three-digit SIC industry, *Number of suppliers* – the number of actual suppliers used by the recalling firm, *Vertical integration dummy* – a dummy variable

[8] Note that not all Transportation Equipment industry recalls are associated with NHTSA recalls. Several of these recalls fall under the purview of CPSC.

[9] We exclude the recalling firm when we compute the average industry leverage.

that takes on a value of one if the firm is vertically integrated, and zero otherwise, *R&D intensity* – R&D expenses as a percentage of total assets, and *Total factor productivity* – a measure of firm's productivity computed using the methodology in Faleye, Mehrotra, and Morck (2006), and *Size* – the logarithm of market value of equity.

The descriptive statistics on the leverage and other variables for the recalling firms are presented in Panels A and B, respectively. In Panel A, the mean (median) *Book leverage* is 0.288 (0.295) and the mean *Market leverage* is 0.313 (0.262). The mean (median) *Firm-to-industry book leverage and Firm-to-industry market leverage* are 1.088 (0.892) and 1.292 (1.085), respectively. Thus, our univariate results suggest that recalling firms have higher leverage than their industry peer firms. In Panel B, the mean (median) *Herfindahl index* of their industry is 0.196 (0.125), suggesting that they operate in reasonably competitive industries. In addition, 7.8% of the recalling firms are vertically integrated, their mean (median) number of dependent suppliers is 15 (4), and their mean (median) R&D intensity is 2.9% (2.5%). Further, their mean (median) total factor productivity is –0.137 (–0.172), suggesting that these firms are not using their factors of production (capital and labor) as effectively as their industry peer firms. We find that the mean (median) cash flow shock for recalling firms is –2.5% (0.2%). Finally, the mean (median) percentage of unionized employees in the recalling firms' three-digit SIC industry is 13.1% (10.3%).

3.3. Stock price reaction to recall announcements: Recalling firms, industry rival firms, and dependent supplier firms

3.3.1. Wealth effects for recalling firms

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 report received date (the date *NHTSA* was made aware of the safety defect), 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 first date of news coverage of the recall event. For matching our recall events to Factiva, we use the name of the recalling firm, the product being recalled, the reason for the recall, and the number of units being recalled. We observe that the recall date that appears in the *CPSC* and *FDA* records almost always coincides with the first instance of the news coverage of the recall in Factiva. Therefore, we use the *CPSC* and *FDA* recall dates for our event study analyses. In the case of automobile recalls, the first news article date was close to the report received date but was well before the date of owner notification. In fact, in almost all instances, we find that the first news article date is the same as the report received date. Therefore, for automobile recalls our event date is the report received date.[10]

To estimate wealth effects of product recalls, we use the event study methodology widely used in the literature. Specifically, we use the market model to estimate parameters of the return generating process of the recalling firms, where the CRSP value-weighted market index is our proxy for the market portfolio. We estimate OLS regression models using daily returns for the recalling firm and the market over our estimation period (which starts 300 trading days and ends 46 trading days before the recall announcement date) to obtain market model parameters. We drop recall events that do not have a minimum of 50 daily returns in the estimation period. The daily abnormal return is the actual return minus the expected return for that day computed from the estimated market model, and cumulative abnormal return (*CAR*) is the sum of the daily abnormal returns over the days in the window under consideration.

To estimate shareholder wealth effects of recalls, we compute cumulative abnormal returns for windows of (–2, +2), (–5, +5), and (–10, +10) trading days around the recall announcement date (*Recalling firm CAR*). Consistent with studies that examine the wealth effects of product recalls, we use wider event

[10] It should be noted that firms do not have much discretion in hiding or strategically delaying recalls given there can be severe criminal and civil penalties for doing so. One example is the then record fine assessed against Toyota by the NHTSA for not reporting in a timely manner the "floor mat pedal entrapment" problem in their 2010 Lexus RX 350 (see http://www.nhtsa.gov; NHTSA 49-12, December 18, 2012). Another is the more recent Volkswagen emission scandal which resulted in a record $21 billion fine against the firm because of their attempting to avoid a recall by hiding emission control problems.

windows than is normally used to measure the announcement effects of other firm events (e.g., Jarrell and Peltzman, 1985; Davidson and Worrell, 1992). The reason for the wider windows in a product recalls context is that some recall announcements are preceded by accidents and other safety issues that arise from product use and, therefore, the possibility of an upcoming recall could be known to the market before the actual recall announcement. So, we study windows ranging from just two days prior to the event and up to ten days prior to the event. In a similar vein, since the extent of the recall-related damage is not always immediately obvious, often even to the firms, we allow for longer post-announcement date windows. Though not tabulated, we also compute the abnormal dollar losses (or gains) as the product of the recalling firm CAR and the market capitalization of the firm's equity before the recall announcement.[11] The announcement-period wealth effects for recalling firms are reported in Column (1) of Table 4.

For the overall sample of all recalls, *Recalling firm CAR* over the (–2, +2), (–5, +5), and (–10, +10) event windows are –0.57%, –1.08%, and –1.47%, respectively. These abnormal returns are statistically significant at the 1% level for each event window, and translate into dollar abnormal returns of –$168.33 million, –$324.57 million, and –$480.51 million over the (–2, +2), (–5, +5), and (–10, +10) event windows, respectively. The magnitudes of the dollar abnormal returns indicate that product recalls are material economic incidents in the lives of corporations.[12]

3.3.2. Wealth effects for industry rival firms

In Column (2) of Table 4, we present the stock price reaction of industry rival firms to recall announcements by recalling firms. As we described earlier, we expect two effects to be at play here. The *competitive effect* would result in positive announcement-period abnormal returns for the rivals as they take advantage of the compromised position of the recalling firm. The *contagion effect* arises when the product

[11] For the (–2, +2) and (–5, +5) windows, we use the market capitalization ten days prior to the recall announcement date, while for the (–10, +10) event window we use the market capitalization twenty days prior to the recall announcement date.
[12] The abnormal returns and associated dollar abnormal returns numbers reported for recalling firms in Table 4 understate their true values because the product recall event for a firm may be partially anticipated by the market based on intrinsic firm characteristics. In our cross-sectional regression analysis of the wealth effects to recalling firms, we also report specifications in which we use anticipation-adjusted abnormal returns as the dependent variable.

recall comes with adverse effects for the industry as a whole, such as increased regulatory attention, or negative perception about the whole product category, or newer packaging or other product standards for all firms in the industry. With the latter, we should observe a negative stock price reaction for the rivals too. If both competitive and contagion effects are in play, then the overall effect on rival firms will depend on which one of these two effects dominates.

To compute the announcement-period abnormal returns for the rivals (*Rival firms' CAR*), we identify rivals as 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. Our proxy for the market portfolio is the CRSP value-weighted market index. Consistent with a net domination of contagion effects over competitive effects, the rival abnormal returns are –0.03%, –0.20%, and –0.40% for the (–2, +2), (–5, +5), (–10, +10) event windows, respectively. Except for the smallest event window (–2, +2), the abnormal returns are statistically significant at least at the 5% level. This result is not surprising considering the evidence in Cohen and Frazzini (2008) who show that there is a delay in relevant information about a firm being reflected in the stock prices of its supply chain firms. Overall, the results suggest that, on average, the contagion effect dominates the competitive effect, and renders a product recall a negative event for the industry as a whole.

3.3.3. Wealth effects for dependent supplier firms

We also examine the abnormal returns to the dependent suppliers of the recalling firms. We identify dependent suppliers by analyzing the Compustat segment tapes of upstream firms. Compustat segment tapes utilize SFAS 14 and SFAS 131 guidelines, which requires public firms to report "key customers" that account for at least 10% of the firm's annual sales. This database, however, only lists customer names and does not have an identifier enabling an easy merge with Compustat. Using both programmed and manual methods, we construct a supplier-customer database for each year in our sample. Using this database, we identify the dependent suppliers of the recalling firms in the two years prior to the recall. For each recalling firm, we then form an equally-weighted portfolio of the firm's dependent suppliers to compute the announcement-period abnormal returns (*Supplier firms' CAR*) 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 dependent suppliers since these firms are largely reliant on sales to the recalling firms. Although suppliers who provide relatively non-specialized inputs may be able to re-tool and supply to the recalling firm's rivals, given the negative impact of the typical recall even on rivals, we expect this possibility to not significantly offset the first-order negative impact of the recall on suppliers.

The abnormal returns upon recall announcements for dependent suppliers of the recalling firm are reported in Column (3) of Table 4. Consistent with our expectation, we observe significant negative abnormal returns for dependent suppliers of recalling firms in all the event windows. For example, the announcement-period abnormal returns are –0.44%, –0.73% and –1.30% over the (-2, +2), (–5, +5) and (–10, +10) event windows, respectively. All these abnormal returns are statistically significant at the 1% level. These results are consistent with the view that product recalls have a significant negative impact on the demand for the products of upstream firms (i.e., the dependent suppliers) and generalizes the findings in Jacobs and Singhal (2020) on the impact of the VW scandal on the tier-1 suppliers of the firm.

4. The relation between relative leverage and the wealth effects of recalling, industry rival firms, and dependent supplier firms around recall announcements

In this section, we examine the effect of relative leverage, i.e., firm-to-industry leverage, on the wealth effects of product recalls on recalling firms, industry rival firms, and dependent suppliers in a multivariate setting.

4.1. Wealth effects of product recall firms and relative leverage

Following the arguments set out in Section 2.2 we expect the relative leverage of a recalling firm to capture not only the financial weakness of the firm, but also the financial strength of the rivals to take advantage of the crisis by engaging in pricing policies or other strategic actions that would steal market share away from the recalling firm. If high relative leverage is indeed a disadvantage to firms, then we expect that the higher the relative leverage of the recalling firm vis-à-vis its industry rivals, the more adverse will be its stock price reaction to recall announcements. Therefore, in the regressions explaining the announcement-period wealth effects of recalls to the recalling firms and those of their rivals and suppliers, we use the ratio of recalling firm leverage to the industry average leverage (either *Firm-to-industry book leverage* or *Firm-to-industry market leverage*) as our primary metric to capture the leverage effects. We use a dummy variable to indicate whether a recall by the firm is the first occurrence of a recall by the firm in our sample (*Initial Recall Dummy*) to control for any incremental reputational effects (either more or less negative) that may be associated with an initial recall. We also control for firm size in all the regressions.

The results from this analysis for recalling firms are reported in Panel A of Table 5. In this table, we report the results for three pairs of regression models. In each pair, the first model (Models 1, 3, and 5) uses *Firm-to-industry book leverage*, while the second model (Models 2, 4, and 6) uses *Firm-to-industry market leverage* as the measure of relative leverage. Further, all reported regressions are estimated using weighted least squares regressions, where the weights are the inverse of the standard deviation of market model residuals. The three pairs of regression models also differ in the choice of dependent variable. In the first pair, the dependent variable is *Recalling firm CAR* measured over the (–2, +2) days event window. Consistent with Hypothesis 1, the coefficients associated with *Firm-to-industry book leverage* (Model 1) and *Firm-to-industry market leverage* (Model 2) are negative and statistically significant at the 1% level.

To the extent that the market can partially anticipate the recall event, *Recalling firm CAR* may not completely capture the wealth effects of the product recall. In our empirical tests, we attempt to control, in two different ways, for the possibility that the recall event is partially anticipated. Both these approaches involve initially modeling the propensity for a product recall using a probit regression model. In the first approach (Models 3 and 4), we control for the propensity of a product recall and, therefore, for the fact that the recall is partially anticipated by the market, by including the inverse Mills ratio in the wealth effects regression. Note that under this approach, *Recalling firm CAR* continues to be the dependent variable in the reported regression models. What we are effectively employing here is a two-stage Heckman selection model. In the first stage, we model the propensity of a product recall while, in the second stage, we model the determinants of the stock price reaction to recalling firms.[13] In the second approach (Models 5 and 6), our dependent variable is *Adjusted Recalling firm CAR*, which is computed as *Recalling firm CAR* divided by (1 – the probability of a product recall), where the probability of a recall is estimated as before using the probit regression. By making this adjustment, we are attempting to capture the wealth effect of a product recall as if it is completely unanticipated.[14]

The control firms used in the first-stage regression model that examines the propensity for a recall are firms in the same three-digit SIC industries as the recalling firms, but did not have a recall over our sample period 2003 – 2013. We follow Kini, Shenoy, and Subramaniam (2017) by using *Market leverage*, *Cash flow shock*, *Unionization*, *Number of suppliers*, *Vertical integration dummy*, *Herfindahl index*, *Total factor productivity*, *R&D intensity*, *Size*, year dummies, and industry dummies as explanatory variables. As an additional control variable in the first stage of the Heckman selection model, for each firm-year in the model we include the proportion of firms in the industry with a recall in that year (excluding the recalling firm). We believe that this variable will be highly correlated with the likelihood of the firm having a recall since we expect to see a higher likelihood of a recall in recall-intensive industries. However, since the proportion of firms with recalls in the industry is likely a function of the regulatory environment or the nature of product, there is little reason to believe that this industry level variable will be directly related to firm-level outcomes such as the announcement-period abnormal returns (other than through its effect on the likelihood of the recall modeled in the first stage).

Our results for the first-stage regression are reported in Appendix Table 1. These results are similar to those reported in Kini, Shenoy, and Subramaniam (2017) and indicate that higher leverage, unionization, number of suppliers, firm size, and industry concentration significantly increase the propensity for a product

[13] See, for example, Cornett, Tanyeri, and Tehranian (2011) for research that uses this approach to control for partial anticipation of an event on wealth effects. Cornett, Tanyeri, and Tehranian (2011) provide a detailed discussion regarding the efficacy of this approach.

[14] Variants of this approach have also been widely used to control for anticipation in assessing the impact of a corporate event on stock prices. For example, Malatesta and Thompson (1985), Krishnaswami and Subramaniam (1999), and Leuz, Triantis, and Wang (2008) use this approach in investigating the value impact of acquisition, spin-off, and voluntary SEC deregistration, respectively.

recall, while higher R&D intensity significantly reduces the propensity for a product recall. Further, the coefficient on the proportion of recalling firms in the industry is significantly positive at the 1% level, thereby indicating that a firm is more likely to have a product recall if a higher proportion of industry peer firms have had recalls in the past.

In Models 3 and 4, we control for anticipation effects by including the inverse Mills from the above first-stage probit model in our second-stage regression models with *Recalling firm CAR* as the dependent variable. The relation between *Recalling firm CAR* and *Firm-to-industry book leverage* (*Firm-to-industry market leverage*) in Model 3 (Model 4) remains significantly negative at the 1% level of significance. In Models 5 and 6, we control for anticipation effects by using an *anticipation-adjusted wealth effects measure* (*Adjusted Recalling firm CAR*) as the dependent variable. This variable is computed as *Recalling firm CAR* divided by (1–the probability of the product recall), where the probability of the product recall is obtained from the above first-stage probit model. In both Models 5 and 6, we find that the relation between *Adjusted Recalling firm CAR* and the specific measure of relative leverage continues to be significantly negative at the 1% level of significance. These results are all consistent with Hypothesis 1 and with the view that recalling firms with higher relative leverage are more likely to be placed at a competitive disadvantage vis-à-vis their rivals because rival firms can more easily take strategic actions to exploit the weakness of the recalling firm. These results are inconsistent with the theories that argue that higher relative leverage makes firms less vulnerable and more aggressive in the product markets.

It is, however, possible that higher relative leverage is the consequence of the firm being financially weaker or having poorer operating efficiency; that is, it is a sign of inherent weakness in the firm. Thus, the wealth effect findings above may simply be the consequence of these other factors and not due to any expected strategic product market actions by industry rivals. To account for this possibility, we additionally control for the prior financial condition (*Cash flow shock* and *Market leverage*) and operating efficiency (*Total factor productivity*) of the firm. The results from this analysis are reported in Panel B of Table 5. We find that the coefficients on *Firm-to-industry book leverage* (*Firm-to-industry market leverage*) are significantly negative at least at the 5% level (1% level) in Models 1, 3, and 5 (Models 2, 4, and 6). In addition, the coefficient on *Cash flow shock* is negative in all six models, but is significantly negative at the 5% level only in Models 1 and 2. The coefficient on *Market leverage* is significantly negative at least at the 5% level in all six models. Taken together, these results suggest that product recalls have greater negative consequences for firms whose financial condition is poorer.[15] Given that our relative leverage results are robust to the inclusion of direct measures of the financial condition and operating efficiency of recalling firms, we can be confident that the adverse wealth consequences of product recalls for firms with higher relative leverage are driven by strategic actions that will likely be undertaken by rival firms.

4.2. Relative leverage and the wealth effects of industry rival firms

We next undertake an 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 (*Rival firms' CAR*) using factors we expect can affect the returns in a multivariate setting. We report three pairs of regression specifications in Table 6; with abnormal returns to the rivals measured over the (–2, +2), (–5, +5), and (–10, +10) windows in the first, second, and third pair of regressions, respectively. The reason for our considering longer windows arises from the findings in Cohen and Frazzini (2008) who analyze the stock prices of economically related firms, such as those of the principal customers of firms. They show that there is a delay in relevant information about a firm being capitalized in the stock prices of supply chain firms. We, therefore, consider longer windows in all rival and supplier regressions.

In the estimated regressions, we examine whether the financial position of the recalling firm has any value consequences for the rival firms. As described in the previous section, we use the variables *Firm-to-industry book leverage* (odd numbered models) *and Firm-to-industry market leverage* (even numbered models) to capture the relative strengths of the recalling firms and their industry rivals and examine their impact on any predation effects. Based on the reasoning behind Hypothesis 2, we expect that when recalling firms are financially weak relative to their rivals, the rivals will benefit more from the recall since predation

[15] The equity of a firm can be viewed as a call option on the firm with the level of debt as the strike price. In this framework, negative shocks to firm value due to product recalls will have a greater impact on the "more levered" equity. The significant negative coefficients on leverage are consistent with this interpretation as well.

of such recalling firms and appropriation of their sales by these rivals is easier following the recalls. Thus, we expect *Firm-to-industry book leverage* and *Firm-to-industry market leverage* measures to have a positive coefficient. We use *Size* and *Initial recall dummy* as control variables in our regressions.

Consistent with Hypothesis 2, the results in Table 6 indicate that the coefficient associated with *Firm-to-industry book leverage* and *Firm-to-industry market leverage* are positive in all six estimated regressions. However, only *Firm-to-industry market leverage* is statistically significant in all the regressions that include it as an independent variable. The coefficient of *Firm-to-industry book leverage* always has a positive sign, but is statistically significant only in the regression with *CAR* from the wider announcement period window. These results are broadly consistent with the view that rival firms stand to gain more in a recall when the recalling firms are relatively more highly levered than their industry counterparts, i.e., when recalling firms are more vulnerable to strategic actions taken by rivals following the recall crisis. This result complements the finding in our previous table that the market expects recalling firms that are financially weaker compared to their rivals to lose more following recalls. The results, however, do not support the opposing view that high relative leverage makes firms stronger competitors and their industry rivals weaker competitors in the product markets.

In addition to the leverage-related competitive effects that are beneficial to rivals firms, it is possible that there are adverse consequences to the rivals due to the contagion effect. If the contagion effect is strong, then a product recall that is bad news for the recalling firm will also be bad news for the rivals. If there are any contagion effects, we should see a positive relation between *Recalling firm CAR* and *Rival firms' CAR* after controlling for relative leverage. Consistent with the contagion effect, the results in Table 6 indicate that *Recalling firm CAR* is positively related to *Rival firms' CAR* in all six estimated regression models. The coefficient associated with *Recalling firm CAR* is significantly positive at the 1% levels in all estimated models that use the longer (–5, +5) and the (–10, +10) announcement-period windows. These results are consistent with the view that there are contagion effects in product recalls.[16] Overall, our results support the

[16] Since *Recalling firm CAR* is related to the relative leverage measures, we estimate two additional specifications for each of the six regressions in Table 6. In the first specification we orthogonalize *Recalling firm CAR* by removing the

notion that rival firms are in a better position to take advantage of the fallout from the product recall event for the recalling firm if the recalling firm has higher relative leverage.

4.3. Relative leverage and the wealth effects of dependent supplier firms

In this section, we examine the determinants of the wealth effects of dependent suppliers (*Supplier firms' CAR*) to announcements of the product recall by a given firm. We again estimate weighted least squares regressions to explain the announcement-period abnormal returns of dependent suppliers using factors we expect can affect these returns in a multivariate setting. The results are reported in Table 7. The format of the table is the same as in Table 6.

Based on the arguments behind Hypothesis 2, we expect that the more financially weak the recalling firm is relative to its industry peers, the lower is its flexibility and ability to deal with the recall, greater are the benefits to its rivals, and so, more adverse are the consequences to suppliers who are dependent on the recalling firm. We, therefore, predict that there should be a negative relation between the abnormal returns to the dependent suppliers and relative leverage of the recalling firm. Further, if the dependent suppliers themselves are highly levered, then a negative shock like a product recall to an important customer should have a greater adverse impact on their own ability to deal with and manage this event. Thus, we expect a negative relation between the abnormal returns to dependent suppliers and their own leverage.

In the product markets literature, *R&D intensity* has been used to proxy for relationship-specific investments between customers and suppliers (see, for example, Allen and Phillips, 2000; Fee, Hadlock, and Thomas, 2006; and Jain, Kini, and Shenoy, 2011). Thus, if the recalling firm's dependent suppliers have greater *R&D intensity*, then it is likely that they have invested heavily in investments that are specific to the recalling (key customer) firm. Therefore, if a negative event like a product recall affects an important customer firm, then switching to a rival is costly for the dependent supplier due to these relationship-specific

component in the variable that is related to the relative leverage measures and use the *Orthogonalized CAR* as the independent variable in place of *Recalling firm CAR*. In the second specification, we drop *Recalling firm CAR* and only include the relative leverage measures along with the control variables in explaining *Rival firms' CAR*. In both sets of regressions, our inferences from Table 6 remain unchanged. Due to space considerations, we do not tabulate these robustness tests in the paper.

investments. The inability to easily switch customers due to these investments implies that any negative shock to an important customer firm will adversely affect dependent suppliers too. This leads to the prediction that the announcement-period abnormal returns of dependent supplier firms will be negatively related to their R&D intensity. As in Tables 5 and 6, *Initial recall dummy* and *Size* are control variables in Table 7 as well.

Consistent with Hypothesis 4, we broadly find evidence of a significantly negative relation between dependent suppliers' abnormal returns and relative leverage. Specifically, the coefficient associated with the specific measure of relative leverage is always in the correct direction (negative), and is significant at least at the 10% level in 5 out of the 6 models and at the 1% level in 3 out of 6 models. These results suggest that if the recalling firm is at a relative disadvantage compared to its rivals, then that represents more bad news for the dependent suppliers of the recalling firm.[17] The coefficient associated with *Supplier leverage* is always negative as predicted but is never statistically significant. In addition, the coefficient on *Supplier R&D intensity* is insignificant in all models.

Finally, we include the recalling firm's abnormal returns as one of the determinants of suppliers' abnormal returns. Including this variable allows us to test whether there are vertical contagion effects. If there is vertical contagion, then there should be a positive relation between the abnormal returns to the dependent suppliers and the abnormal returns to the recalling firm, i.e. dependent suppliers' losses are larger when the recalling firm's losses are higher. We find that the coefficient on the abnormal returns to the recalling firms is significantly positive at the 1% level in all six estimated models, which is consistent with the view that suppliers suffer more when recalling firms' losses are greater.[18]

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[17] Our inferences about relative leverage do not change if we include measures of prior financial condition (*Cash flow shock* and *Market leverage*) and operating efficiency (*Total factor productivity*) in the *Rival firms' CAR* and *Supplier firms' CAR* regressions.

[18] Similar to the robustness tests for the determinants of *Rival firms' CAR*, we conduct equivalent robustness tests for the *Supplier firms' CAR* as well in Table 7. That is, since *Recalling firm CAR* is related to the relative leverage measures, we estimate two additional specifications for each of the six regressions in Table 7. As before, in the first specification we orthogonalize *Recalling firm CAR* by removing the component in the variable that is related to the relative leverage measures and use the *Orthogonalized CAR* as the independent variable in place of *Recalling firm CAR*. In the second specification, we drop *Recalling firm CAR* and only include the relative leverage measures along with the control variables in explaining *Supplier firms' CAR*. In both sets of regressions, all the results are qualitatively similar to the results in Table 7. Due to space considerations, we do not tabulate these robustness tests in the paper.

5. The effect of relative leverage on the value impact of recalls: The role of product market risk

We had earlier hypothesized that we expect relative leverage of recalling firms to be a significant determinant of recalling firm and rival wealth effects but mainly in economic environments where the strategic effects of debt are likely to be more important, i.e., when the firm faces greater product market risk. We use a novel metric termed "product market fluidity" developed by Hoberg, Phillips, and Prabhala (2014) to capture the product market risk faced by a firm. Specifically, they construct this measure as the cosine similarity between changes in rival firms' product descriptions in relation to the firm's product descriptions. They argue that a higher value for product market fluidity reflects greater competitive threats from rivals and, thus, suggests that the firm is exposed to higher product market risk (*PM Risk*).

We examine the relation between the announcement-period wealth effects for recalling firms and relative leverage for sub-samples of recalling firms based on *PM Risk* in Table 8. Specifically, we sub-divide recalling firms into terciles based on each of the above measures and then estimate regressions separately for recalling firms in the top tercile and the bottom tercile of the measure. In each table, odd (even) numbered models contain the regression results for the sub-sample of recalling firms in the top (bottom) tercile of the measure. In addition, in all three tables, the dependent variable is *Recalling firm CAR* in Models 1–4 and *Adjusted Recalling firm CAR* in Models 5–8, both measured over the (–2, +2) days announcement-period event window. Finally, the relative leverage measure is *Firm-to-industry book leverage* in Models 1, 2, 5, and 6 and *Firm-to-industry market leverage* in Models 3, 4, 7, and 8. The difference between the estimated regression models in the two panels is that the models in Panel B additionally control for the financial condition (*Cash flow shock* and *Market leverage*) and operating efficiency (*Total factor productivity*) of the firm.

In Panel A of Table 8, we find that the coefficients associated with our relative leverage measures are significantly negative (all at the 1% level) only in the high *PM Risk* sub-sample. Overall, even though relative leverage of the recalling firm is significantly negatively related to the announcement period wealth effects of recalling firms for the full sample of recalls (Table 5), the results in Panel A indicate that this effect is confined only to the subsample of firms with high product market risk (fluidity). Thus, the results are consistent with Hypothesis 5, which captures the notion that the relative leverage of recalling firms has an adverse impact on the announcement-period wealth effects of recalling firms mainly in economic environments where the strategic effects of debt are likely to be more important. In Panel B, we again observe that the relation between wealth effects and relative leverage is only significantly negative in the high *PM Risk* sub-sample. Specifically, the coefficients on *Firm-to-industry book leverage* (*Firm-to-industry market leverage*) are significantly negative at the 10% (1%) level in Models 1 and 3 (Models 5 and 7). Importantly, the coefficients on *Market leverage* are consistently significantly negative for both high and low *PM Risk* subsamples and, thus, suggest that these effects are unrelated to product market competition. Taken together, these results illustrate that relative leverage and leverage capture two distinct avenues through which recalls affect firm value, with relative leverage capturing the effect of potential strategic actions by rivals and firm leverage reflecting the effect of the recalling firm's financial condition.

We examine the relation between the announcement-period wealth effects for industry rival firms and relative leverage of recalling firms for sub-samples of recalling firms based on *PM Risk* in Table 9. As before, we sub-divide recalling firms into terciles based on *PM Risk* and then estimate regressions separately for recalling firms in the top tercile and the bottom tercile of the measure. The dependent variable in all estimated regression models in this table is *Rival firms' CAR* measured over the (–2, +2), (–5, +5), and (–10, +10) days announcement-period event window in Panel A, Panel B, and Panel C, respectively. In each panel, the relative leverage measure is *Firm-to-industry book leverage* in Models 1 and 2 and *Firm-to-industry market leverage* in Models 3 and 4.

In Table 9 we find that the coefficients associated with our relative leverage measures are consistently positive in the high *PM Risk* sub-sample (significantly different from zero at least at the 10% level in five of the six reported regressions for this sub-sample). Consistent with the findings in Cohen and Frazzini (2008) of a delayed market reaction of material events for focal firms on their related supply chain firms due to the information and time it may take to assess the full impact of the event on related third parties, we find that the above reported results tend to get stronger for the longer event windows. Again, in line with predictions in Hypothesis 5, we find that the relative leverage of recalling firms has a positive impact on the announcement-period wealth effects for industry rival firms only in economic environments where rivals' predation-related benefits are likely to be high.

In summary, our findings show that both our main results – (i) a significant negative relation between recalling firm's relative leverage and wealth effects to the recalling firms and (ii) a significant positive relation between recalling firm's relative leverage and wealth effects to industry rivals – are confined to economic environments where theory predicts the strategic effects of debt are likely to be more important. These results are consistent with Hypothesis 5. But more importantly, these sub-sample results suggest a possible causal relation between relative leverage and value effects because it is unlikely that a spurious correlation is also selectively present for firms that are predicted by theory to be more adversely affected by higher relative leverage (recalling firms operating in economic environments where strategic effects of debt are likely to be present) *and* more favorably affected by higher relative leverage (industry rival firms of recalling firms operating in economic environments where strategic effects of debt are likely to be present).

6. The effect of relative leverage on the market share impact of product recalls

In this section, we focus on the product market consequences of relative leverage for recalling firms. Specifically, we examine the relation between the change in market share (*Change in market share*) for recalling firms and relative leverage. To examine this question, we build a panel of recalling and non-recalling firms for each year over our sample period 2003-2013. Non-recalling firms are firms without a product recall in the sample period. For every firm, we count the number of recalls it has during each year (*Recall frequency*). Thus, for any given year, *Recall frequency* will always be zero for non-recalling firms; for recalling firms, it will be the number of recalls that year (which can equal zero if it had no recalls in that year). A higher value of *Recall frequency* suggests a more severe recall environment for the firm. We compute *Change in market share* as the market share of the recalling firm in year *t+1* minus the market share in year *t-1*, where year *t* is the recall announcement year. The market share of the recalling firm is calculated as its revenues divided by the sum of the revenues of all firms in the three-digit SIC industry of the firm. The main independent variables are *Relative leverage* (either *Firm-to-industry book leverage* or

Firm-to-industry market leverage), *Recall frequency*, *and Relative leverage* × *Recall frequency*. Hypothesis 3 predicts that the coefficient on the interaction term, *Relative leverage* × *Recall frequency*, should be significantly negative. The results from this analysis are reported in Table 10. We subsequently examine whether the intensity of product market threats has a bearing on this relation. Hypothesis 6 predicts that the coefficient on the interaction term, *Relative leverage* × *Recall frequency*, should be significantly negative only for the high *PM Risk* subsample. The results from this analysis are reported in Table 11.[19]

In all the regressions reported in Table 10, the dependent variable is *Change in market share*. The key independent variables are our two measures of relative leverage. Models 1 and 3 (Models 2 and 4) employ relative leverage based on book (market) leverage. In Models 1 and 2, we only include *Size* as a control variable, whereas in Models 3 and 4, we additionally include controls for the firm's financial condition (*Cash flow shock* and *Market leverage*) and operating efficiency (*Total factor productivity*). Consistent with Hypothesis 3, the estimated coefficients on *Relative leverage* × *Recall frequency* are significantly negative at least at the 1% level in all four models. This finding suggests that a firm with higher relative leverage will feel greater pressure on its market share from strategic actions taken by its competitors if it has a more severe recall environment. The coefficient on *Market leverage* is significantly negative in Models 3 and 4 at the 1% level, suggesting that more financially constrained firms will suffer greater market share losses. Notably, controlling for financial condition and operating efficiency does not affect the magnitude or significance of the coefficient on *Relative leverage* × *Recall frequency*.

In Table 11, we report the results from eight regression models, the odd (even) numbered models are estimated using the subsample of recalling firms with high (low) *PM Risk*. In Models 1, 2, 5, and 6

[19] Univariate statistics of the *Change in market share* variable highlight a stark difference between recalling firms that operate in highly competitive environments and those that operate in not so competitive environments. There is an economically significant decline in market share following recalls for recalling firms operating in environments where strategic interactions between firms in an industry are more important (i.e., the high product market risk subsample). Specifically, recalling firms with high *PM Risk* experience a 0.73% drop in market share, while those in the low *PM Risk* subsample experience an increase of 0.11% in market share. When viewed in comparison to the mean market shares of 8.18% in the high *PM Risk* subsample and 15.36% in the low *PM Risk* subsample, they constitute a 8.92% drop (-0.73/8.18) and 0.72% increase (0.11/15.36) in market share, respectively. This difference is consistent with the view that recalls have strategic product market consequences. In the interests of brevity, we do not tabulate these numbers.

(Models 3, 4, 7, and 8), the relative leverage measure is based on book (market) leverage. In Models 1-4, we only include *Size* as a control variable, whereas in Models 5-8, we additionally include controls for the firm's financial condition (*Cash flow shock* and *Market leverage*) and operating efficiency (*Total factor productivity*). Consistent with Hypothesis 6, the coefficients *Relative leverage* × *Recall frequency* are significantly negative at the 1% level in the high *PM Risk* subsample (Models 1, 3, 5, and 7) and insignificant in the low *PM Risk* subsample (Models 2, 4, 6, and 8). Note that the coefficient on *Market leverage* is significantly negative at least at the 5% level for both the high and low *PM Risk* subsamples, suggesting that poorer financial condition has an adverse impact on market share, but that this effect is unrelated to the intensity of product market threats faced by the firm. Overall, these results provide corroborating evidence that the product market consequences of high relative leverage increase with recall frequency. Further, consistent with the view that strategic product market effects are at play, this impact is confined to settings where recalling firms face greater product market risk.[20]

7. Summary and conclusions

Prior research has shown that product recalls are material events in the life of a firm and they result in significant negative wealth effects for the recalling firm due to the direct costs of the recall and due to the expected indirect costs such as reputational damage, regulatory penalties, and damages to be paid to victims. In this paper, we examine whether there is another significant cost to the recalling firms, which arises due to the vulnerability of the competitive position of the recalling firm vis-à-vis its industry rivals. Specifically, we empirically test the theories that argue that this cost is dependent on the financial position of the recalling firm relative to its rivals and is confined to product markets where competitive effects are expected to be high.

We find that announcements of products recalls are associated with negative wealth effects for recalling firms. Further, we find a negative relation between the announcement-period wealth effects of

[20] Our conclusions do not change if we replace *Recall frequency* with *Recall dummy* in Tables 10 and 11. *Recall dummy* always take the value zero for non-recalling firms. It, however, takes the value of one for a given year if the recalling firm has at least one recall in that year, and zero otherwise. The results from this analysis are presented in Internet Appendix Tables 1 and 2.

recalling firms and relative leverage. This result is consistent with the view that the market expects recalling firms with higher relative leverage to suffer greater losses, perhaps due to predatory strategic actions taken in response to the recall by its financially less-constrained industry rivals. These results obtain even after controlling for the recalling firm's prior financial condition and operating efficiency. As further corroborating evidence, we find that rivals benefit more from the recall when the recalling firm's relative leverage is higher. This is consistent with the view that there are more predation-related benefits to rivals when they are dealing with financially vulnerable recalling firms. These findings are reinforced by our analysis of the change in market share in recalling and non-recalling firms. We find that there is a more significant drop in market share for firms with higher frequency of recalls that also have higher relative leverage, which suggests that the adverse consequences of recalls are at least partly driven by strategic product market effects. When analyzing suppliers' stock price reaction to the recall, we find evidence that the suppliers are worse off when relative leverage of recalling firms is larger – highlighting the negative consequences of relying on key customer firms that are financially weaker than their rivals.

To provide further support that the valuation consequences of relative leverage are capturing competitive effects, we document that a higher relative leverage leads to more negative wealth effects for recalling firms and more positive wealth effects for their rivals only in economic environments where firms face higher product market risk. The above results are further reinforced by our finding that the adverse market share consequence of product recalls increase with high relative leverage only in settings where firms face greater product market threats. Overall, our results suggest that firms experiencing product failures are vulnerable to strategic responses by industry rivals when their relative leverage is high, especially when the recalling firms are subject to significant competitive threats.

Finally, once we control for the strategic effects faced by the recalling firm, we find evidence that the stock price reaction of industry rival firms and dependent suppliers are positively related to the recalling firm's stock price reaction. Thus, bad news for the recalling firm is viewed in the market as bad news for the rivals and suppliers – alluding to negative spillover effects from the recall. These results indicate that product recalls have both horizontal (industry-wide) and vertical (supplier) contagion effects.

Our study makes contributions to the product quality, product markets, and supply chain literatures. First, given the sample is large and is from over a 100 different three-digit SIC code industries, we are able to provide generalizable inferences about the wealth effects of recalls for recalling firms, their industry rivals, and their dependent suppliers. Second, we show evidence of horizontal and vertical contagion effects associated with product recalls. Third, our paper is the first study to provide evidence that the relative financial position of a firm plays a key role in determining the valuation consequences of a recall. Finally, the availability of product recalls data across multiple industries enables us to test the contention that relative financial leverage influences strategic actions of firms mainly in certain product market environments. Overall, our paper makes a key contribution to the product quality literature by showing that the adverse impact of a product recall on the competitive position of the firm is an additional cost of quality failures.

Appendix

We provide below the detailed descriptions of the variables used in the paper.

I. Variables used to predict the propensity of product recalls

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*, we divide the numerator by the sum of the book value of debt (Compustat item *DLTT* + Compustat item *DLC*) and market value of equity (Compustat item *CSHO* × Compustat item *PRCC_F*) for the year prior to the recall announcement year.

b. *Herfindahl index*

It is the sum of the squared market shares of all firms in the same three-digit SIC industry as the recalling (control) firm for the year prior to the recall announcement year.

c. Unionization

It 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 the recall announcement. The rates of unionization are obtained from *Union Stats* website available at http://www.unionstats.com.

d. Number of suppliers

Number of Suppliers is the number of dependent 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

To construct the *Vertical integration dummy* we use an approach that is inspired by the methodology in Fan and Lang (2000) and Fan and Goyal (2006). Vertical integration dummy is an indicator variable that is set to 1 if any segment of the firm belongs to an industry that sources 5% or more of its inputs from another industry in which the firm also has a segment. Segment level information is obtained from Compustat segment tapes. 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. R&D intensity

It 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.

g. 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 item *PPENT*). We then compute *TFP* as the residual from this regression for the firm.

h. *Cash flow shock*

We follow Kini, Shenoy, and Subramaniam (2017) to calculate *Cash flow shock*. Specifically, we first compute *Cash flow* as income before extraordinary items (Compustat item *IB*) plus depreciation (Compustat item *DP*) minus change in net working capital (using Compustat items *INVT*, *RECT*, *ACO*, and *LCO*) minus capital expenditures (Compustat item *CAPX*) divided by market value of assets, which is calculated as book value of debt (Compustat item *DLC* plus Compustat item *DLTT*) plus market value of equity (Compustat item *CSHO* × Compustat item *PRCC_F*). We then compute *Cash flow shock* as cash flow for the year prior to announcement [$Cash\ flow_{t\text{-}1}$] less the average value of cash flows over the prior three years [average of $Cash\ flow_{t\text{-}2}$, $Cash\ flow_{t\text{-}3}$, and $Cash\ flow_{t\text{-}4}$].

i. *Size*

It is the natural logarithm of the market capitalization calculated as shares outstanding × fiscal year end share price [Compustat item *CSHO* × Compustat item *PRCC_F*] of the recalling (control) firm.

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

a. *Firm-to-industry book (market) leverage*

Firm-to-industry book leverage is the ratio of the book leverage of the recalling firm to the book leverage of the recalling firm's industry peers. In a similar fashion, *Firm-to-industry market leverage* is the ratio of market leverage of the recalling firm to the market leverage of the industry peers. We compute the book (market) leverage of the recalling firm's industry peers (*Industry book (market) leverage*) as the average of *Book (Market) leverage* of all firms in the recalling firm's three-digit SIC industry. We exclude the recalling firm in the computation of the industry level measure of leverage.

b. *Initial recall dummy*

It 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.

III. *Variables capturing product market competitiveness and effects*

PM Risk

PM Risk is the product market fluidity measure developed in Hoberg, Phillips, and Prabhala (2014). It is computed as the cosine similarity between changes in rival firms' product descriptions in relation to the firm's product descriptions.

Change in market share

Change in market share is the market share of the recalling firm in year *t+1* minus the market share in year *t-1*, where year *t* is the recall announcement year. *Market share* of a firm is calculated as the firm's revenues divided by the sum of the revenues of all firms in the three-digit SIC industry of the firm.

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Table 1

Frequency of product recalls

This table provides the frequency of product recalls by public firms regulated by the Food and Drug Administration (*FDA*), the Consumer Product Safety Commission (*CPSC*), and the National Highway Traffic Safety Administration (*NHTSA*) over the period of 2003 – 2013.

	Frequency of product recalls			
Year of recall	*NHTSA*	*FDA*	*CPSC*	Overall
2003	53	0	10	63
2004	102	13	63	178
2005	58	8	86	152
2006	39	53	63	155
2007	30	59	91	180
2008	20	63	56	139
2009	15	88	46	149
2010	32	92	53	177
2011	63	23	59	145
2012	71	16	39	126
2013	61	22	45	128
Total	544	437	611	1,592

Table 2

Distribution of the frequency of product recalls by industry

This table contains information on the number of product recalls by publicly traded firms in each two-digit SIC industry over the period 2003 – 2013.

Two-digit SIC	Description of industry	Frequency of recalls
1	Agricultural Production Crops	8
2	Agriculture production livestock and animal specialties	3
13	Oil and gas extraction	1
20	Food and Kindred Products	117
22	Textile Mill Products	1
23	Apparel and Other Finished Products Made from Fabrics	13
24	Lumber and Wood Products, Except Furniture	2
25	Furniture and Fixtures	13
26	Paper and Allied Products	2
27	Printing, Publishing, And Allied Industries	4
28	Chemicals and Allied Products	178
29	Petroleum Refining and Related Industries	1
30	Rubber and Miscellaneous Plastics Products	14
31	Leather and Leather Products	6
32	Stone, Clay, Glass, And Concrete Products	4
33	Primary Metal Industries	1
34	Fabricated Metal Products, Except Machinery and Transportation Equipment	19
35	Industrial and Commercial Machinery and Computer Equipment	100
36	Electronic & Other Electrical Equipment and Components, Except Computer Equipment	64
37	Transportation Equipment	590
38	Measuring, Analyzing, And Controlling Instruments	91
39	Miscellaneous Manufacturing Industries	51
47	Transportation Services	3
48	Communications	7
50	Wholesale Trade-durable Goods	4
51	Wholesale Trade-non-durable Goods	6
52	Building Materials, Hardware, Garden Supply, And Mobile Home Dealers	4
53	General Merchandise Stores	100
54	Food Stores	46
55	Automotive Dealers and Gasoline Service Stations	4
56	Apparel and Accessory Stores	24
57	Home Furniture, Furnishings, And Equipment Stores	41
58	Eating and Drinking Places	11
59	Miscellaneous Retail	20
73	Business Services	2
80	Health Services	5
99	Non-classifiable Establishments	32

Table 3

Descriptive statistics on characteristics of recalling firms

This table provides descriptive statistics on characteristics of public firms that recall their products over the period 2003 – 2013. Our key variables are *Firm-to-industry book leverage* and *Firm-to-industry market leverage*. We compute *Book (Market) leverage* as the book (market) value of debt divided by total assets. *Industry book (market) leverage* is the average of *Book (Market) leverage* of all firms in the recalling firm's three-digit SIC industry. We exclude the recalling firm in the computation of the industry level measure of leverage. Finally, *Firm-to-industry book (market) leverage* is the ratio of the *Book (Market) leverage* to *Industry book (market) leverage* of the recalling firm. The descriptions of all the other variables are provided in the Appendix.

Panel A: Leverage-related variables				
Variable name	N	Mean	Median	Std. Dev.
Book leverage	1,592	0.288	0.295	0.172
Market leverage	1,592	0.313	0.262	0.250
Firm-to-industry book leverage	1,591	1.088	0.892	1.440
Firm-to-industry market leverage	1,591	1.292	1.085	1.493

Panel B: Other firm and industry variables				
Variable name	N	Mean	Median	Std. Dev.
PM Risk	1,154	5.64	4.705	3.4912
Cash flow shock	1,578	-0.025	0.002	0.233
Herfindahl index	1,592	0.196	0.125	0.155
Unionization	1,592	0.131	0.103	0.108
Number of suppliers	1,592	15.090	4.000	26.563
Vertical integration dummy	1,553	0.078	0.000	0.268
R&D intensity	1,592	0.029	0.025	0.033
Total factor productivity	1,574	-0.137	-0.172	0.513
Size	1,592	9.409	9.908	1.831

Table 4

Announcement-period wealth effects for recalling firms

This table presents the average announcement-period wealth effects of the recall events for the recalling firms (*Recalling firm CAR*), industry rival firms (*Rival firms' CAR*), and dependent suppliers of recalling firms (*Supplier firms' CAR*). 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. FASB 14 mandates firms to report the names of all customers who account for a significant proportion of their sales. We can, thus, identify the dependent suppliers of recalling firms from the Compustat database. *Recalling firm CAR* is the cumulative abnormal return for the recalling firm over each event window. We compute the rival (dependent supplier) portfolio returns as equally weighted returns of all rival (dependent supplier) firms prior to computing *Rival (Supplier) firms' CAR* for the (-2, +2), (-5, +5), and (-10, +10) event windows around the recall announcement date. Z-statistics are provided in the parentheses and are used to test whether the mean value of *CAR*s are significantly different from zero. N is the number of recall events or portfolios of rivals/ suppliers. ***, ** and * indicate significance at 1%, 5%, and 10%, respectively.

	Recalling firms Column (1)	Industry rivals Column (2)	Supplier firms Column (3)
	N=1,592	N=1,566	N=1,110
Event windows	*Recalling firm CAR* (%)	*Rival firms' CAR* (%)	*Supplier firms' CAR* (%)
(-2, +2)	-0.57***	-0.03	-0.44***
	(-4.88)	(-0.70)	(-4.01)
(-5, +5)	-1.08***	-0.20**	-0.73***
	(-7.03)	(-2.57)	(-4.43)
(-10, +10)	-1.47***	-0.40***	-1.30***
	(-7.51)	(-3.26)	(-5.75)

Table 5

The impact of relative leverage on the announcement-period wealth effects of recalling firms

This table presents results for the determinants of the announcement-period abnormal returns to recalling firms. The dependent variable in Models 1-2 is the cumulative abnormal return (*Recalling firm CAR*) measured over the (-2, +2) day event window around the recall announcement date. In Models 3-4, we report results from the second stage of the Heckman two-stage estimation procedure. In the first stage of the Heckman selection model (results reported in Appendix Table 1), the dependent variable is *RecallDum* which takes the value one (zero) for firms in the recalls (control) sample. The control sample consists of firms that are in the same three-digit SIC industry as the recalling firms, but did not have a product recall over the entire sample period. In addition, to satisfy exclusion restrictions of the Heckman selection model, for each firm-year we compute the proportion of firms in the industry (excluding the recalling firm) with a recall that year and include it as an instrumental variable. In the second stage, the dependent variable is *Recalling firm CAR* and weighted least squares estimations are followed. The *Inverse Mills Ratio* is calculated based on the first stage estimation of the likelihood of a product recall. In Models 5-6, the dependent variable is anticipation adjusted *CAR* (*Adjusted Recalling firm CAR*) computed as *Recalling firm CAR* divided by (1 – probability of the recall), where the probability of recall is computed using the probit model specified in Appendix Table 1. We use weighted least squares estimations in Models 1-6, where the weights are the inverse of the standard deviation of market model residuals. All *CAR*s are measured in percentage units. *Firm-to-industry book leverage* is the ratio of the book leverage of the recalling firm to the book leverage of the recalling firm's industry peers. *Firm-to-industry market leverage* is the ratio of the market leverage of the recalling firm to the market leverage of the recalling firm's industry peers. The recalling firm is not considered in computing the industry level measures of leverage. All other independent variables are defined in the Appendix. In addition to the relative leverage measure, Panel A includes *Size*, and *Initial recall dummy* as independent variables. The regressions reported in Panel B additionally include *Cash flow shock*, *Market leverage*, and *TFP* as independent variables. The *p*-values are reported in parentheses. They are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10%, respectively.

Panel A: Dependent variable	*Recalling firm CAR*				*Adjusted Recalling firm CAR*	
	(1)	(2)	(3)	(4)	(5)	(6)
Firm-to-industry book leverage	-0.0623***		-0.0670***		-0.6133***	
	(0.007)		(0.008)		(0.000)	
Firm-to-industry market leverage		-0.0840***		-0.0860***		-0.6988***
		(0.000)		(0.001)		(0.000)
Size	0.0647	0.0691	-0.0022	0.0011	-0.4361	-0.4044
	(0.274)	(0.238)	(0.981)	(0.990)	(0.111)	(0.135)
Initial recall dummy	-0.2190	-0.2267	-0.1405	-0.1484	-0.0021	-0.0565
	(0.332)	(0.314)	(0.590)	(0.569)	(0.998)	(0.940)
Inverse mills ratio			-0.2227	-0.2244		
			(0.277)	(0.268)		
Constant	-0.6675	-0.6943	0.2057	0.1882	8.2215	8.2528
	(0.343)	(0.318)	(0.850)	(0.861)	(0.105)	(0.102)
Calendar year dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.03	0.03	0.03	0.03	0.02	0.03
Observations	1,591	1,591	1,534	1,534	1,519	1,519

Continued…

Table 5 (Continued)

Panel B: Dependent variable	*Recalling firm CAR*				*Adjusted Recalling firm CAR*	
	(1)	(2)	(3)	(4)	(5)	(6)
Firm-to-industry book leverage	-0.0399**		-0.0419**		-0.4282***	
	(0.043)		(0.038)		(0.001)	
Firm-to-industry market leverage		-0.0546***		-0.0457***		-0.4404***
		(0.001)		(0.004)		(0.002)
Size	0.0577	0.0567	-0.0989	-0.0941	-0.3327	-0.3433
	(0.332)	(0.338)	(0.239)	(0.260)	(0.207)	(0.195)
Initial recall dummy	-0.3640	-0.3542	-0.2388	-0.2379	-1.2493	-1.1861
	(0.136)	(0.147)	(0.370)	(0.371)	(0.126)	(0.142)
Cash flow shock	-0.4603**	-0.4615**	-0.2620	-0.2747	-1.0933	-1.1478
	(0.020)	(0.019)	(0.231)	(0.206)	(0.257)	(0.233)
Market Leverage	-0.9680**	-0.8812**	-1.4492***	-1.3726***	-7.8342***	-7.3266***
	(0.010)	(0.020)	(0.001)	(0.002)	(0.000)	(0.000)
TFP	-0.1983	-0.2113	-0.2285	-0.2381	-0.5085	-0.5990
	(0.279)	(0.249)	(0.214)	(0.197)	(0.408)	(0.334)
Inverse mills ratio			-0.5291**	-0.5074**		
			(0.023)	(0.030)		
Constant	0.2509	0.2391	1.6757	1.5909	11.4830**	11.4412**
	(0.800)	(0.809)	(0.113)	(0.130)	(0.028)	(0.028)
Calendar year dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.04	0.04	0.04	0.04	0.03	0.03
Observations	1,572	1,572	1,534	1,534	1,519	1,519

Table 6

The impact of relative leverage on the 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 rivals of recalling firms. The sample period is 2003 – 2013. The dependent variable is the cumulative abnormal return for the rival portfolio (*Rival firms' CAR*) measured over the (-2, +2), (-5, +5), or (-10, +10) day event window around the recall announcement date. *Firm-to-industry book (market) leverage* is the ratio of the book (market) leverage of the recalling firm to the book (market) leverage of the recalling firm's industry peers. The recalling firm is not considered in computing the industry level measures for leverage. *Recalling firm CAR* is the cumulative abnormal return for the recalling firm over the (-2, +2), (-5, +5), or (-10, +10) day event window. All *CAR*s are measured in percentage units. *Size* is the lagged logarithm of the market value of equity of the recalling firm. *Initial recall dummy* is a dummy variable that equals one if the product recall is the first by the recalling firm during our sample period and equals zero otherwise. The *p*-values are reported in parentheses. They 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)	(5)	(6)
Dep. variable: *Rival firms' CAR*	(-2,+2)	(-2,+2)	(-5,+5)	(-5,+5)	(-10,+10)	(-10,+10)
Firm-to-industry book leverage	0.0304		0.0353		0.0876*	
	(0.187)		(0.270)		(0.066)	
Firm-to-industry market leverage		0.0444**		0.0580*		0.1021*
		(0.021)		(0.080)		(0.057)
Recalling firm CAR (-2, +2)	0.0145	0.0148				
	(0.443)	(0.433)				
Recalling firm CAR (-5, +5)			0.0512***	0.0516***		
			(0.001)	(0.001)		
Recalling firm CAR (-10, +10)					0.0522***	0.0526***
					(0.002)	(0.002)
Size	-0.0356	-0.0365	0.0136	0.0121	-0.0630	-0.0640
	(0.369)	(0.355)	(0.805)	(0.826)	(0.471)	(0.464)
Initial recall dummy	-0.2671*	-0.2636	0.0558	0.0610	0.1033	0.1084
	(0.095)	(0.100)	(0.820)	(0.805)	(0.783)	(0.774)
Constant	-0.0011	-0.0208	-0.9372	-0.9635	-0.7642	-0.8063
	(0.998)	(0.967)	(0.181)	(0.165)	(0.469)	(0.442)
Calendar year dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.01	0.01	0.01	0.01	0.02	0.02
Observations	1,562	1,562	1,562	1,562	1,562	1,562

Table 7

The impact of relative leverage on the announcement-period wealth effects of dependent suppliers

This table presents the weighted least squares estimation results for the determinants of the announcement-period abnormal returns to dependent suppliers of recalling firms. The sample period is 2003 – 2013. The dependent variable is the cumulative abnormal return for the supplier portfolio (*Supplier firms' CAR*) measured over the (-2, +2), (-5, +5) or (-10, +10) day event window around the recall announcement date. *Firm-to-industry book (market) leverage* is the ratio of the book (market) leverage of the recalling firm to the book (market) leverage of the recalling firm's industry peers. The recalling firm is not considered in computing the industry level measures for leverage. *Supplier leverage* is the lagged supplier portfolio book leverage. *Supplier R&D intensity* is the lagged supplier portfolio research & development intensity. *Recalling firm CAR* is the cumulative abnormal return for the recalling firm over the (-2, +2), (-5, +5) and (-10, +10) event window. All *CAR*s are measured in percentage units. *Size* is the lagged logarithm of the market value of equity of the recalling firm. *Initial recall dummy* is a dummy variable that equals one if the product recall is the first by the recalling firm during our sample period and equals zero otherwise. The *p*-values are reported in parentheses. They 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)	(5)	(6)
Dep. variable: *Supplier firms' CAR*	(-2,+2)	(-2,+2)	(-5,+5)	(-5,+5)	(-10,+10)	(-10,+10)
Firm-to-industry book leverage	-0.0578***		-0.0427**		-0.1129***	
	(0.000)		(0.015)		(0.007)	
Firm-to-industry market leverage		-0.0466***		-0.0091		-0.0769*
		(0.000)		(0.600)		(0.083)
Recalling firm CAR (-2, +2)	0.1132***	0.1129***				
	(0.001)	(0.001)				
Recalling firm CAR (-5, +5)			0.1361***	0.1364***		
			(0.000)	(0.000)		
Recalling firm CAR (-10, +10)					0.1266***	0.1266***
					(0.000)	(0.000)
Supplier R&D intensity	-0.2943	-0.1297	0.5046	0.6573	-2.0352	-1.6964
	(0.826)	(0.923)	(0.792)	(0.731)	(0.391)	(0.476)
Supplier leverage	-0.3845	-0.4475	-1.5693	-1.4943	-2.3379	-2.3928
	(0.680)	(0.631)	(0.296)	(0.317)	(0.193)	(0.184)
Size	-0.0931	-0.1008	-0.1365	-0.1442	-0.0295	-0.0456
	(0.302)	(0.261)	(0.274)	(0.240)	(0.845)	(0.764)
Initial recall dummy	-0.0939	-0.1077	-0.3273	-0.3259	-0.6763	-0.6963
	(0.768)	(0.737)	(0.483)	(0.486)	(0.341)	(0.331)
Constant	1.2030	1.3117	2.5941	2.6174	2.2075	2.3876
	(0.268)	(0.223)	(0.108)	(0.104)	(0.254)	(0.229)
Calendar year dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.05	0.05	0.07	0.07	0.07	0.07
Observations	1,108	1,108	1,108	1,108	1,108	1,108

Table 8

Relative leverage and the wealth effects of recalling firms: Subsamples based on recalling firm product market risk

This table presents results for the determinants of the announcement-period abnormal returns to recalling firms split by recalling firm product market fluidity. We sub-divide the recalling firms into two groups based on the *Product market fluidity* measure developed by Hoberg, Phillips, and Prabhala (2014). Firms in the top tercile are considered to be in a high product market risk environment (*High PM Risk.*) and firms in the bottom tercile are considered to be in a low product market risk environment (*Low PM Risk*). The dependent variable in Models 1 –4 is the cumulative abnormal return (*Recalling firm CAR*) measured over the (-2, +2) event window around the recall announcement date. In Models 5 – 8, the dependent variable is anticipation adjusted *Recalling firm CAR* (*Adjusted Recalling firm CAR*) measured as in Cornett, Tanyeri, and Tehranian (2011). All *CAR*s are measured in percentage units. Weighted least squares estimations are followed. *Size* is the lagged logarithm of the market value of equity. *Firm-to-industry book (market) leverage* is the ratio of the book (market) leverage of the recalling firm to the book (market) leverage of the recalling firm's industry peers. The recalling firm is not considered in computing the industry level measures for leverage. *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. *Size* is the lagged logarithm of the market value of equity of the recalling firm. *Inverse Mills Ratio* is calculated based on the first stage estimation of the likelihood of a product recall (see Appendix Table 1). The *p*-values are reported in parentheses. They are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10%, respectively.

Panel A: Dependent Variable	*Recalling firm CAR*				*Adjusted Recalling firm CAR*			
	High PM Risk	*Low PM Risk*	*High PM Risk*	*Low PM Risk*	*High PM Risk*	*Low PM Risk*	*High PM Risk*	*Low PM Risk*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Firm-to-industry book leverage	-0.0788***	0.0014			-0.7468***	-0.0256		
	(0.005)	(0.990)			(0.000)	(0.945)		
Firm-to-industry market leverage			-0.0823***	-0.2640			-0.7552***	-0.7469
			(0.000)	(0.117)			(0.000)	(0.143)
Size	-0.1260	0.2924**	-0.1126	0.2703*	-0.4627	-0.3238	-0.3624	-0.3256
	(0.327)	(0.044)	(0.374)	(0.056)	(0.354)	(0.433)	(0.405)	(0.413)
Initial recall dummy	-0.0210	-0.1807	-0.0201	-0.2145	0.1006	0.8629	0.1470	0.7149
	(0.965)	(0.632)	(0.967)	(0.559)	(0.929)	(0.482)	(0.898)	(0.527)
Inverse mills ratio	-0.6106*	0.6780*	-0.6057*	0.6003*				
	(0.082)	(0.053)	(0.086)	(0.071)				
Constant	1.1793	-4.5671**	1.0714	-3.8853*	3.9415	0.3224	21.6316***	1.3900
	(0.461)	(0.049)	(0.495)	(0.082)	(0.477)	(0.936)	(0.000)	(0.732)
Calendar year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	373	382	373	382	373	369	373	369
R-squared	0.08	0.04	0.08	0.04	0.10	0.01	0.10	0.02

Continued…

Table 8 (Continued)

Panel B: Dependent Variable	*Recalling firm CAR*				*Adjusted Recalling firm CAR*			
	High PM Risk	*Low PM Risk*	*High PM Risk*	*Low PM Risk*	*High PM Risk*	*Low PM Risk*	*High PM Risk*	*Low PM Risk*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Firm-to-industry book leverage	-0.0509*	0.0566			-0.6202***	0.2545		
	(0.070)	(0.644)			(0.000)	(0.621)		
Firm-to-industry market leverage			-0.0456*	-0.0445			-0.6140***	0.7108
			(0.057)	(0.825)			(0.000)	(0.245)
Market Leverage	-1.8276**	-1.8287***	-1.7579**	-1.6730**	-7.6280**	-8.8633***	-6.7578*	-10.3098***
	(0.010)	(0.004)	(0.016)	(0.027)	(0.047)	(0.000)	(0.065)	(0.000)
Cash Flow Shock	-0.3150	-0.4933	-0.3125	-0.4882	-1.8763	-1.7076	-1.6795	-1.4987
	(0.421)	(0.698)	(0.433)	(0.691)	(0.122)	(0.567)	(0.111)	(0.615)
TFP	-0.3305	-0.4171	-0.3302	-0.3894	-1.9061	-0.1618	-1.9516	-0.0740
	(0.287)	(0.313)	(0.295)	(0.325)	(0.113)	(0.851)	(0.113)	(0.938)
Size	-0.2633*	0.2202	-0.2534*	0.2268*	-0.7184	-0.1053	-0.6551	-0.0055
	(0.051)	(0.109)	(0.062)	(0.097)	(0.164)	(0.766)	(0.185)	(0.989)
Initial recall dummy	-0.0380	-0.4144	-0.0328	-0.3926	-0.5309	-0.6258	-0.3520	-0.6793
	(0.940)	(0.307)	(0.948)	(0.336)	(0.651)	(0.499)	(0.770)	(0.482)
Inverse mills ratio	-0.9384**	0.4979	-0.9153**	0.4844				
	(0.018)	(0.141)	(0.022)	(0.139)				
Constant	3.1659*	-2.7847	6.9862***	-2.7845	7.7905	3.1620	29.3549***	2.3317
	(0.068)	(0.205)	(0.000)	(0.204)	(0.205)	(0.393)	(0.000)	(0.568)
Calendar year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	373	382	373	382	373	369	373	369
R-squared	0.10	0.06	0.10	0.05	0.11	0.03	0.11	0.03

Table 9

Relative leverage and the wealth effects of rival firms: Subsamples based on recalling firm product market risk

This table presents the weighted least squares estimation results for the determinants of the announcement-period abnormal returns to rivals of recalling firms split by product market fluidity of recalling firms. *Product market fluidity* is developed by Hoberg, Phillips, and Prabhala (2014). Rival portfolios in the top tercile of *Product market fluidity* are considered to be in a high product market risk environment (*High PM Risk.*) and firms in the bottom tercile of *Product market fluidity* are considered to be in a low product market risk environment (*Low PM Risk*). The sample period is 2003 – 2013. The dependent variable is the cumulative abnormal return for the rival portfolio (*Rival firms' CAR*) measured over the (-2, +2), (-5, +5), and (-10, +10) event window around the recall announcement date in Panel A, Panel B, and Panel C, respectively. All *CAR*s are measured in percentage units. *Firm-to-industry book (market) leverage* is the ratio of the book (market) leverage of the recalling firm to the book (market) leverage of the recalling firm's industry peers. The recalling firm is not considered in computing the industry level measures for leverage. *Recalling firm CAR* is the cumulative abnormal return for the recalling firm over the (-2, +2), (-5, +5) and (-10, +10) event window. Control variables include *Size* and the *Initial recall dummy*. All estimations contain calendar year dummies. The *p*-values are reported in parentheses. They are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10%, respectively.

Panel A: Dependent variable is *Rival firms' CAR* computed over the (-2, +2) days event window

Dep. Variable: *Rival firms' CAR*	*High PM risk* (-2, +2)	*Low PM risk* (-2, +2)	*High PM risk* (-2, +2)	*Low PM risk* (-2, +2)
Firm-to-industry book leverage	0.0265	0.1121		
	(0.300)	(0.192)		
Firm-to-industry market leverage			0.0534**	0.0797
			(0.026)	(0.519)
Recalling firm CAR (-2, +2)	0.0454	0.0052	0.0460	0.0064
	(0.133)	(0.876)	(0.128)	(0.850)
Control variables	Yes	Yes	Yes	Yes
R-squared	0.05	0.03	0.06	0.02
Observations	382	388	382	388

Panel B: Dependent variable is *Rival firms' CAR* computed over the (-5, +5) days event window

Dep. Variable: *Rival firms' CAR*	*High PM risk.* (-5, +5)	*Low PM risk.* (-5, +5)	*High PM risk.* (-5, +5)	*Low PM risk.* (-5, +5)
Firm-to-industry book leverage	0.0573*	-0.1954		
	(0.078)	(0.120)		
Firm-to-industry market leverage			0.0614**	-0.1125
			(0.040)	(0.541)
Recalling firm CAR (-5, +5)	0.0382	0.0899**	0.0384	0.0856**
	(0.161)	(0.035)	(0.158)	(0.044)
Control variables	Yes	Yes	Yes	Yes
R-squared	0.05	0.05	0.05	0.05
Observations	382	388	382	388

Panel C: Dependent variable is *Rival firms' CAR* computed over the (-10, +10) days event window

Dep. Variable: *Rival firms' CAR*	*High PM risk.* (-10, +10)	*Low PM risk.* (-10, +10)	*High PM risk.* (-10, +10)	*Low PM risk.* (-10, +10)
Firm-to-industry book leverage	0.1148***	-0.2183		
	(0.004)	(0.320)		
Firm-to-industry market leverage			0.1109***	-0.2416
			(0.009)	(0.415)
Recalling firm CAR (-10, +10)	0.0585**	0.1028***	0.0582**	0.1005***
	(0.021)	(0.009)	(0.022)	(0.009)
Control variables	Yes	Yes	Yes	Yes
R-squared	0.05	0.07	0.05	0.07
Observations	382	388	382	388

Table 10

Relative leverage and the change in market share of recalling firms

This table presents ordinary least squares estimation results for the determinants of the change in market share for recalling and control firms. The sample period is 2003 – 2013. The dependent variable is *Change in market share* which is the difference in market share of the recalling firm over the (*t-1*, *t+1*) year window around the recall announcement year *t*. Market share of the firm is calculated as firm revenues divided by revenues of all firms in the three-digit SIC industry of the firm, and is expressed in percentage units. *Firm-to-industry book (market) leverage* is the ratio of the book (market) leverage of the recalling firm to the book (market) leverage of the recalling firm's industry peers. The recalling firm is not considered in computing the industry level measures for leverage. *Recall frequency* is the number of recalls in year t for recalling firms and is zero for non-recalling firms. All independent variables are lagged by one year. The *p*-values are reported in parentheses. They are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10%, respectively.

Dependent variable: *Change in market share*	(1)	(2)	(3)	(4)
Firm-to-industry book leverage ($\times 10^{-6}$)	-0.0055***		-0.0055***	
	(0.000)		(0.000)	
Recall frequency	0.0188	0.0608	0.0352	0.0785
	(0.661)	(0.323)	(0.422)	(0.209)
Firm-to-industry book leverage × Recall frequency	-0.0525***		-0.0513***	
	(0.001)		(0.001)	
Firm-to-industry market leverage ($\times 10^{-6}$)		0.0185**		0.0248***
		(0.042)		(0.000)
Firm-to-industry market leverage × Recall frequency		-0.0544***		-0.0543***
		(0.000)		(0.000)
Size	-0.0078	-0.0080	-0.0100	-0.0102
	(0.461)	(0.439)	(0.383)	(0.367)
Market leverage			-0.3315***	-0.3249***
			(0.000)	(0.000)
Cash flow shock			-0.0103	-0.0101
			(0.166)	(0.162)
TFP			-0.0041	-0.0036
			(0.768)	(0.790)
Constant	-0.2076***	-0.1961***	-0.1484***	-0.1095**
	(0.000)	(0.000)	(0.008)	(0.038)
Calendar year dummies	Yes	Yes	Yes	Yes
R-squared	0.01	0.01	0.01	0.02
Observations	31,180	31,348	29,762	29,882

Table 11

Relative leverage and change in market share: Sub-samples based on recalling firms' product market risk

This table presents ordinary least squares estimation results for the determinants of the change in market share for recalling and control firms. The sample period is 2003 – 2013. The dependent variable is *Change in market share* which is the difference in market share of the recalling firm over the (*t-1, t+1*) year window around the recall announcement year *t*. Market share of firm is calculated as firm revenues divided by revenues of all firms in the three-digit SIC industry of the firm, and is expressed in percentage units. *Firm-to-industry book (market) leverage* is the ratio of the book (market) leverage of the recalling firm to the book (market) leverage of the recalling firm's industry peers. The recalling firm is not considered in computing the industry level measures for leverage. *Recall frequency* is the number of recalls in year t for recalling firms and is zero for non-recalling firms. All independent variables are lagged by one year. The *p*-values in reported in parentheses. They are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10%, respectively.

Dependent variable: *Change in market share*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	High PM Risk	*Low PM Risk*	*High PM Risk*	*Low PM Risk*	*High PM Risk*	*Low PM Risk*	*High PM Risk*	*Low PM Risk*
Firm-to-industry book leverage ($\times 10^{-6}$)	-0.0055***	0.0119			-0.0055***	0.0497		
	(0.000)	(0.633)			(0.000)	(0.112)		
Recall frequency	0.0664	-0.0111	0.1712*	0.2570	0.0716	-0.0011	0.1580*	0.2368
	(0.224)	(0.939)	(0.050)	(0.214)	(0.195)	(0.994)	(0.070)	(0.252)
Firm-to-industry book leverage × Recall frequency	-0.1759***	0.1169			-0.1664***	0.1107		
	(0.000)	(0.321)			(0.000)	(0.345)		
Firm-to-industry market leverage ($\times 10^{-6}$)			0.0306***	-0.0031***			0.0305***	-0.0030***
			(0.000)	(0.000)			(0.000)	(0.000)
Firm-to-industry market leverage × Recall frequency			-0.1388***	-0.0870			-0.1254***	-0.0743
			(0.000)	(0.237)			(0.000)	(0.311)
Size	-0.0386**	-0.0368	-0.0386**	-0.0368	-0.0334*	-0.0432	-0.0336*	-0.0397
	(0.036)	(0.195)	(0.035)	(0.199)	(0.080)	(0.144)	(0.077)	(0.182)
Market leverage					-0.5307***	-0.5062***	-0.5298***	-0.3179**
					(0.000)	(0.002)	(0.000)	(0.023)
Cash flow shock					0.0066	-0.0537	0.0066	-0.0519
					(0.268)	(0.483)	(0.263)	(0.503)
TFP					-0.0146	-0.0162	-0.0136	-0.0157
					(0.358)	(0.699)	(0.390)	(0.708)
Constant	0.0720	-0.1311	0.0687	-0.1813	0.1311	-0.1335	0.1285	-0.1314
	(0.399)	(0.378)	(0.414)	(0.165)	(0.164)	(0.339)	(0.168)	(0.352)
Calendar year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.03	0.02	0.03	0.02	0.04	0.03	0.04	0.02
Observations	7,317	7,448	7,317	7,450	7,201	7,374	7,201	7,374

Appendix Table 1
First-stage probit regressions to predict recall incidence

This table presents results from a probit regression model to predict the incidence of a product recall by a public firm over the sample period 2003 – 2013. The dependent variable is *RecallDum* which equals one for firms in the recall sample, and zero for firms in the control sample. The control sample consists of firms that belong to the same three-digit SIC industry as the recalling firms but do not have a product recall over our sample period. To satisfy exclusion restrictions of the Heckman selection model, for each firm-year we compute the proportion of firms in the industry (excluding the recalling firm) with a recall that year and include it as an instrumental variable. We include this variable *Proportion industry recall* in the regression. The detailed description of how we construct each independent variable in the regression below is provided in the Appendix. The *p*-values are reported in parentheses. They are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10%, respectively.

Dep. Variable: Recall incidence	(1)
Market leverage	0.9478***
	(0.000)
Unionization	0.0133*
	(0.066)
Number of suppliers	0.0291***
	(0.000)
Vertical integration dummy	-0.0963
	(0.573)
R&D intensity	-1.6420**
	(0.041)
TFP	0.0456
	(0.450)
Herfindahl index	1.3543***
	(0.000)
Cash flow shock	-0.1475
	(0.130)
Size	0.4372***
	(0.000)
Proportion industry recall	1.3047***
	(0.000)
Constant	-5.4879***
	(0.000)
Industry and year dummies	Yes
Observations	29,507

Internet Appendix Tables

Internet Appendix Table 1. Relative leverage and the change in market share of recalling firms

Internet Appendix Table 2. Relative leverage and the change in market share of recalling firms: Sub-samples based on recalling firms' product market risk

Internet Appendix Table 1
Relative leverage and the change in market share of recalling firms

This table presents ordinary least squares estimation results for the determinants of the change in market share for recalling and control firms. The sample period is 2003 – 2013. The dependent variable is *Change in market share* which is the difference in market share of the recalling firm over the (*t-1*, *t+1*) year window around the recall announcement year *t*. Market share of firm is calculated as firm revenues divided by revenues of all firms in the three-digit SIC industry of the firm, and is expressed in percentage units. *Firm-to-industry book (market) leverage* is the ratio of the book (market) leverage of the recalling firm to the book (market) leverage of the recalling firm's industry peers. The recalling firm is not considered in computing the industry level measures for leverage. *RecallDum* equals one for recalling firms and zero for non-recalling firms. All independent variables are lagged by one year. The *p*-values are reported in parentheses. They are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10%, respectively.

Dependent variable: *Change in market share*	(1)	(2)	(3)	(4)
Firm-to-industry book leverage ($\times 10^{-6}$)	-0.0055***		-0.0054***	
	(0.000)		(0.000)	
Recall dummy	0.4283*	0.4522*	0.4741*	0.4944*
	(0.092)	(0.085)	(0.063)	(0.060)
Firm-to-industry book leverage × Recall dummy	-0.1079***		-0.1045***	
	(0.001)		(0.001)	
Firm-to-industry market leverage ($\times 10^{-6}$)		0.0184**		0.0246***
		(0.040)		(0.000)
Firm-to-industry market leverage × Recall dummy		-0.1123***		-0.1072***
		(0.000)		(0.000)
Size	-0.0133	-0.0129	-0.0162	-0.0158
	(0.202)	(0.208)	(0.154)	(0.160)
Market leverage			-0.3509***	-0.3435***
			(0.000)	(0.000)
Cash flow shock			-0.0093	-0.0094
			(0.212)	(0.196)
TFP			-0.0012	-0.0009
			(0.933)	(0.945)
Constant	-0.1920***	-0.1823***	-0.1264**	-0.0890*
	(0.000)	(0.000)	(0.023)	(0.087)
Calendar year dummies	Yes	Yes	Yes	Yes
R-squared	0.01	0.01	0.02	0.02
Observations	31,180	31,348	29,762	29,882

Internet Appendix Table 2

Relative leverage and the change in market share: Sub-samples based on recalling firms' product market risk

This table presents ordinary least squares estimation results for the determinants of the change in market share for recalling and control firms. The sample period is 2003 – 2013. The dependent variable is *Change in market share* which is the difference in market share of the recalling firm over the (*t-1*, *t+1*) year window around the recall announcement year *t*. Market share of firm is calculated as firm revenues divided by revenues of all firms in the three-digit SIC industry of the firm, and is expressed in percentage units. *Firm-to-industry book (market) leverage* is the ratio of the book (market) leverage of the recalling firm to the book (market) leverage of the recalling firm's industry peers. The recalling firm is not considered in computing the industry level measures for leverage. *RecallDum* equals one for recalling firms and zero for non-recalling firms. All independent variables are lagged by one year. The *p*-values are reported in parentheses. They are based on heteroskedasticity robust standard errors and are clustered by firm. ***, ** and * indicate significance at 1%, 5%, and 10%, respectively.

Dependent variable: *Change in market share*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	High PM Risk	*Low PM Risk*	*High PM Risk*	*Low PM Risk*	*High PM Risk*	*Low PM Risk*	*High PM Risk*	*Low PM Risk*
Firm-to-industry book leverage ($\times 10^{-6}$)	-0.0056***	0.0150			-0.0055***	0.0529*		
	(0.000)	(0.547)			(0.000)	(0.097)		
Recall dummy	0.3383	0.2785	0.2420	0.5285	0.3337	0.2856	0.1878	0.4860
	(0.176)	(0.490)	(0.409)	(0.201)	(0.176)	(0.478)	(0.526)	(0.241)
Firm-to-industry book leverage × Recall dummy	-0.6534***	0.0676			-0.6170***	0.0553		
	(0.000)	(0.761)			(0.000)	(0.802)		
Firm-to-industry market leverage ($\times 10^{-6}$)			0.0307***	-0.0032***			0.0306***	-0.0030***
			(0.000)	(0.000)			(0.000)	(0.000)
Firm-to-industry market leverage × Recall dummy			-0.3954**	-0.1442			-0.3439**	-0.1134
			(0.021)	(0.511)			(0.040)	(0.606)
Size	-0.0378**	-0.0404	-0.0371**	-0.0402	-0.0325*	-0.0464	-0.0319*	-0.0432
	(0.044)	(0.156)	(0.046)	(0.159)	(0.096)	(0.117)	(0.099)	(0.145)
Market leverage					-0.5343***	-0.5037***	-0.5339***	-0.3207**
					(0.000)	(0.002)	(0.000)	(0.019)
Cash flow shock					0.0063	-0.0507	0.0058	-0.0500
					(0.296)	(0.508)	(0.333)	(0.518)
TFP					-0.0152	-0.0164	-0.0142	-0.0155
					(0.341)	(0.696)	(0.373)	(0.711)
Constant	0.0699	-0.1217	0.0638	-0.1710	0.1285	-0.1270	0.1238	-0.1207
	(0.416)	(0.415)	(0.454)	(0.185)	(0.176)	(0.355)	(0.190)	(0.384)
Calendar year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.03	0.02	0.03	0.02	0.04	0.03	0.04	0.02
Observations	7,317	7,448	7,317	7,450	7,201	7,374	7,201	7,374