PRODUCT RECALL CONTAGION IN THE SUPPLY CHAIN

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ABSTRACT

Following a manufacturer's large product recall, its supplier's shareholders may perceive uncertain future demand for the supplier's products and react punitively, causing a drop in the supplier's stock return—i.e., a contagion (or negative spillover). Moreover, the shareholders' information asymmetry may cause them to "screen" the supplier's information cues to determine the supplier's extent of demand uncertainty. The ideal screen is the supplier's proportion of sales revenue from the recalling manufacturer. However, not all suppliers disclose this information. Therefore, we propose that shareholders apply a two-stage screening. The first screen is whether the supplier showed transparency by voluntarily disclosing information about its portfolio of customers. The second screen—only available for the subset of suppliers that disclose customer information—is the supplier's sales revenue from the recalling manufacturer. We used a sample of 896 U.S. public manufacturer-supplier dyads impacted by 27 large manufacturer recalls. An event study followed by cross-sectional regressions provides evidence of contagion. In addition, it reveals that the supplier's voluntary disclosure of customer information mitigates contagion, whereas revenue dependence aggravates it. Contextual (i.e., recall) variables also impact contagion. Our research study contributes to the supply-chain contagion literature, screening theory, and customer information disclosure literature. Practically, the findings inform supplier firms' managers that their prior customer-related disclosures and the contextual variables can moderate contagion.

Keywords: contagion, product recall, supply chain, disclosure of customer information

INTRODUCTION

Manufacturer-supplier relations are intertwined (e.g., Hertzel, Li, Officer, and Rodgers 2008). A supplier may become more prosperous because of a manufacturer's success (e.g., Li and Simcoe 2021; Van Everdingen, Fok, and Stremersch 2009), but also suffer steep losses resulting from the manufacturer's failure (e.g., Hertzel, Li, Officer, and Rodgers 2008; Kolay, Lemmon, and Tashjian 2016). For example, the manufacturer's product recall—notably a large one—can spur a sharp, near-term drop in the demand for the manufacturer's products (Borah and Tellis 2016; Giannetti and Srinivasan 2021; Liu and Shankar 2015) and, by extension, forecast uncertain demand for the supplier's products. This *demand uncertainty* can translate into a drop in the supplier's imminent cash flows. Anticipating this uncertainty, the supplier's shareholders would likely drive down its stock price. Thus, a manufacturer's recall likely causes a *contagion* (or negative spillover) on the supplier's shareholder value (Fang et al. 2024). Unsurprisingly, the supplier's managers would want to know which prior customer-related disclosures may influence shareholders' perceptions of demand uncertainty, thus mitigating or aggravating their punitive reactions. Our research answers this question.

We reason that the supplier's shareholders attempt to resolve their uncertainty about the demand for the supplier's products by "screening" for supplier-provided "cues" about its customers (Connelly, Shi, Cheng, and Yin 2021). Thus, we rely on *screening theory*[1] (Riley 2001; Stiglitz 1975; Zhang, Shi, and Connelly 2023) to explore a supplier's prior (i.e., in the pre-recall period) information cues that may lower its shareholders' perceived demand uncertainty.

The ideal screen provides information about the supplier's dependence on the recalling manufacturer-customer for sales revenue. However, this information is often unavailable. Specifically, the U.S. federal law requires a U.S. public firm to disclose revenue from and the name of a customer that contributed at least 10% of the supplier's annual sales revenue (i.e., the customer is "major"). Further, the law states that the firm's disclosure of a "minor" customer's information is voluntary. Interestingly, the Financial Accounting Standards Board (FASB) states that the supplier's disclosure of major customers' information is voluntary (Web Appendix A quotes the law and the FASB). Prior research has shown that many firms do not disclose customer information, and the U.S. Securities and Exchange Commission (SEC) has never taken disciplinary action in response to such law violations (e.g., Ellis, Fee, and Thomas 2012). Therefore, the supplier's shareholders often cannot find information about the supplier's revenue dependence on the recalling manufacturer-customer.

We reason that the supplier's shareholders overcome the unavailability of their preferred screen by undertaking a two-stage screening. First, they check whether the supplier *voluntarily* disclosed customer information by going above and beyond the legal requirements and the accounting standards. The intuition is that the supplier's mere voluntary disclosure of customer information

[1] Screening theory explains decision-makers' search for and use of secondary information that can overcome information asymmetry under conditions of uncertainty and thus assists them in making decisions (Zhang, Shi, and Connelly 2023, p. 1).

assuages its shareholders' perceived demand uncertainty after the manufacturer's recall, mitigating their punitive reactions. Second, in cases where the supplier discloses customer information, shareholders screen the supplier's revenue dependence on the recalling manufacturer. The intuition is that the higher the supplier's dependence, the greater the shareholders' perceived demand uncertainty and, thus, the more punitive their reactions.

Furthermore, the contextual recall variables may serve as a shareholder screen (Connelly, Shi, Cheng, and Yin 2021; Qian, Crilly, Wang, and Wang 2021). Prior research on shareholder reactions to automotive recalls (e.g., Eilert, Jayachandran, Kalaignanam, and Swartz 2017; Mukherjee, Ball, Wowak, Natarajan, and Miller 2022) has positioned recall severity as the most relevant shareholder screen because it ties directly to customer demand for the recalled product and its components. Therefore, we follow this research to consider an exhaustive set of five proxies of recall severity: recall size, recall news volume, recall news sentiment, customer harm, and software (vs. non-software) recall (Astvansh and Eshghi 2024; Astvansh, Suri, and Damavandi 2024).

We test our conjectures in the context of 896 U.S. public manufacturer-supplier dyads affected by 28 large recalls announced by 11 manufacturers, which contract with 46 suppliers. Following recall research in operations management (e.g., Mukherjee, Ball, Wowak, Natarajan, and Miller 2022; Thirumalai and Sinha 2011) and marketing (e.g., Chen, Ganesan, and Liu 2009; Liu, Shankar, and Yun 2017), we measure a supplier's shareholders reactions by the supplier's cumulative abnormal stock return (CAR) surrounding on the date of the manufacturer's recall. Next, we estimate two cross-sectional regressions. The first one regresses the supplier's CAR on whether the supplier voluntarily disclosed information about its customers in the year immediately preceding the recall year, and recall severity proxies. The second regression—estimated on the subsample of suppliers who disclosed their sales revenue from the recalling manufacturer—regresses the CAR on the supplier's revenue dependence (Jacobs and Singhal 2020; Jacobs, Singhal, and Zhan 2022; Qiu, Xu, Yeung, and Zeng 2024).

The event study reports that, on average, a manufacturer-customer's large recall causes its supplier's stock returns to drop by 0.40%. Thus, evidence supports supply-chain contagion from recalls . Next, the first cross-sectional regression reports that shareholders are *less* punitive toward suppliers that disclosed (vs. those that did not disclose) customer information in the year before the recall year. Contextual variables—specifically, recall size, recall news volume, and recall news sentiment—are also associated with shareholder reactions. The second cross-sectional regression reports that the higher the supplier's revenue dependence on the recalling customer, the *more* punitive the shareholders' reaction. Thus, the second screen also reduces shareholders' uncertainty, albeit in an unfavorable direction for the supplier because it strengthens the possibility that the supplier will experience a greater loss in demand.

As we elaborate in the discussion section, our findings contribute to (1) supply-chain contagion literature, (2) screening theory, and (3) customer information disclosure literature. First, we extend

supply-chain contagion literature (see Table B1 in Web Appendix B) by documenting that a supplier's prior customer-related disclosures and recall contextual variables can influence shareholders' uncertainty, and by extension, their punitive reactions. These findings also inform recall literature that a recall's consequences can propagate in the supply chain (Astvansh, Antia, and Tellis 2024a, 2024b; Cleeren, van Heerde, and Dekimpe 2017). Second, we contribute to screening theory by proposing a two-stage screening procedure when shareholders' ideal screen is unavailable and demonstrating that the screens in the two stages impact their reactions asymmetrically. Third, we expand the sparse literature on how customer information disclosure affects a firm's shareholder value (Ellis, Fee, and Thomas 2012; He, Chen, and Chan 2022). We show the double-edged nature of this disclosure in the context of a recall's supply-chain contagion.

Our findings advise supplier firms' managers on managing shared supply-chain contagion. On the one hand, anticipating potential supply-chain contagion, the supplier's managers may highlight their firm's customer information disclosure to assuage shareholders' perceptions that the manufacturer's recall may hurt the demand for the supplier's products. On the other hand, our findings alert managers to the disclosure's potential downside because it reveals revenue dependence on a recalling manufacturer whose product demand is likely to drop significantly. Further, our findings show that suppliers that decide not to disclose customer information can rely on firm- and recall-specific characteristics to mitigate supply-chain contagion.

CONCEPTUAL FRAMEWORK

Shareholders' Two-Stage Screening to Mitigate Demand Uncertainty

Information asymmetry "arises between those who hold information and those who could make better decisions if they had it" (Qian, Crilly, Wang, and Wang 2021, p. 529). In our context, a supplier to a recalling manufacturer holds private information about its customer portfolio. This information is unavailable to the supplier's shareholders. The shareholders' need for this information becomes salient when a manufacturer-customer issues a large recall. Prior research has shown that a large recall is likely to cause a sharp and immediate decline in the demand for (1) the recalled product (Cleeren, Van Heerde, and Dekimpe 2013; Liu and Shankar 2015), (2) the manufacturer's non-recalled products (Giannetti and Srinivasan 2021; Liu and Shankar 2015), and (3) other products in the focal product category (Borah and Tellis 2016). This evidence provides the supplier's shareholders with a reason to interpret/assume the manufacturer's recall as an increase in the uncertainty surrounding the demand for the supplier's products. The increase in shareholders' perceived demand uncertainty prompts them to infer that the supplier's future cash flows are at risk. The inference drives down the supplier's stock price (Chen, Ganesan, and Liu 2009; Liu, Shankar, and Yun 2017). The customer recall's negative effect on the supplier's shareholder value is called *contagion* (or negative spillover). Table B1 in Web Appendix B summarizes the supply-chain contagion literature.

The supplier's shareholders may reduce their perceived demand uncertainty by screening the supplier-provided information cues about its customer portfolio, and by extension, the demand for its products (Connelly et al. 2021; Spence 1974; Stiglitz 1975). In our substantive context, screening refers to the supplier's shareholders using the supplier's observable cues to determine the level of demand uncertainty the supplier may face due to its manufacturer-customer's recall (Panagopoulos, Mullins, and Avramidis 2018).

The ideal screen is the supplier's dependence on the recalling manufacturer-customer for sales revenue (Jacobs, Singhal, and Zhan 2022; Jacobs and Singhal 2020; Qiu, Xu, Yeung, and Zeng 2024). The higher the supplier's revenue dependence on the recalling customer, the greater is the proportion of a supplier's cash flows exposed to risk. Therefore, dependence should aggravate shareholders' punitive reactions. However, publicly listed firms in the United States do not necessarily report their sales revenue from customers (see Web Appendix A). Therefore, the supplier's shareholders cannot rely exclusively on the revenue dependence screen.

We propose that shareholders adopt a two-stage screening process to circumvent the unavailability of the revenue dependence cue. The first stage involves determining whether the focal supplier disclosed customer information in the year before the recall year. If the answer is affirmative, shareholders move to the second stage, using the screen of the supplier's revenue dependence on the recalling customer. More concretely, shareholders consider the proportion of annual sales revenue the supplier received from the recalling manufacturer-customer.

Stage 1: Supplier's Voluntary Disclosure of Customer Information

A supplier may *voluntarily* disclose proprietary information about its customer portfolio if its anticipated disclosure benefits outweigh its foreseen proprietary costs (Ellis, Fee, and Thomas 2012; He, Chen, and Chan 2021). Disclosure benefits involve reducing shareholders' information asymmetry (Bayer, Tuli, and Skiera, 2017) and thus seeking favorable perceptions (Li, 2010; Ling, Yu, and Zhang, 2020). Shareholders of a disclosing supplier may screen for its voluntary disclosure of customer information, and thus become aware of its alternatives to the recalling manufacturer-customer. Consequently, they can more precisely estimate the supplier's demand uncertainty triggered by the manufacturer's recall, leading them to react less punitively. However, the disclosed information is also available to the firm's rivals, who become aware of the supplier's customers and may poach them, resulting in a decline in the supplier's sales revenue (Bayer, Tuli, and Skiera, 2017). This plausibility leads the firm to anticipate the disclosure's proprietary costs.

We acknowledge the plausibility that shareholders may interpret the disclosure as managerial overconfidence and fear that the disclosure may cause rivals to poach customers, inducing greater (rather than lesser) demand uncertainty. Should this interpretation prevail, shareholders may react more punitively when the supplier voluntarily discloses customer portfolio information.

Stage 2: Supplier's Revenue Dependence on the Recalling Manufacturer-Customer

The contagion literature suggests that the magnitude of propagation of a recall's costs to a supplier is a function of the supplier's level of dependence on the recalling manufacturer-customer (Pfeffer and Salancik 1978). The three factors of (1) importance, (2) discretion, and (3) number of alternatives, which compose resource dependence (Pfeffer and Salancik 1978), suggest that revenue dependence is a diagnostic screen for the supplier's shareholders when a manufacturer-customer issues a large recall. First, the supplier relies on its manufacturer-customers for revenue, a critical resource that defines the supplier's ability to survive and grow (Heide and John 1988). Second, customers have discretion over which suppliers they form relations with and whose contracts they terminate when faced with financial difficulties (Maitland, Bryson, and Van de Ven 1985; Wathne and Heide 2000). Third, a customer that contributes a larger revenue share for the supplier is more difficult to replace than a smaller customer (Casciaro and Piskorski 2005; Emerson 1962). Thus, the greater the supplier's revenue dependence on the recalling customer, the more uncertain the demand for the supplier's products. Thus, revenue dependence may exacerbate shareholders' punitive reactions.

Recall Context's Effect on Shareholder Reactions

Shareholders may also look up the "contextual variables" as a screen. Therefore, we consider recall severity—the most relevant recall variable—as a shareholder screen (Cleeren, van Heerde, and Dekimpe 2017; Gao, Xie, Wang, and Wilbur 2015; Liu and Shankar 2015).

Recall severity is multifaceted (Cleeren, van Heerde, and Dekimpe 2017). Thus, we focus on five recall variables that shareholders may use to mitigate their perceived uncertainty. First, we examine recall size, defined as the number of affected products (Gao, Xie, Wang, and Wilbur 2015). A larger recall typically signals a broader customer reach, increasing the potential impact on brand reputation and product-market performance. Second, we examine the extent of the recall's news volume (Borah and Tellis 2016; Liu and Shankar 2015). News media exposure amplifies recall visibility, intensifying its deleterious effects on customers and shareholders. Third, we consider the news sentiment. Negative media portrayals amplify reputational damages, leading to more punitive shareholder reactions (Tetlock 2007). Fourth, we also account for customer harm (Chakravarty, Saboo, and Xiong 2022), as recalls linked to bodily injury or death can significantly undermine customer trust, eroding shareholder confidence. Fifth, we examine the effect of software-related defects to account for cases where the recall is relatively simple to address (e.g., upgrading) compared to nonsoftware-related defects.

DATA AND METHOD

Data

Measuring recalls' contagion from a manufacturer-customer to a supplier requires an empirical setting where manufacturer-suppliers are interdependent in the product market (Cho, DeMiguel, and

Hwang 2021). The automotive industry meets this requirement because suppliers produce 70% of an automobile, on average (McGee 2017), suggesting high interdependence.

An automotive supplier's shareholders may expect recalls to be frequent events (Astvansh, Ball, and Josefy 2022; Crouch, Pourazad, and Ke 2021; Stout 2019). Consequently, a manufacturer's recall that affects a few automobiles will elicit little or no reaction from the supplier's shareholders (Jarrell and Peltzman 1985). Indeed, many automobile recall studies sample "large" recalls (e.g., Gao, Xie, Wang, and Wilbur 2015; Giannetti and Srinivasan 2022; Hoffer, Pruitt, and Reilly 1988; Jarell and Peltzman 1985; Javadinia, Gill, and Jayachandran 2023; Liu and Varki 2021; Pupovac, Carrillat, and Michayluk 2021). Consistent with these precedents, we sample *large* recalls, defined as recalls that affect at least 1 million vehicles (Beattie, Durante, Knight, and Sen 2021). These recalls are large enough to attract a supplier's shareholders' attention and frequent enough to create uncertainty about the demand for the supplier's products.

We assembled our sample in three steps. (1) We identified large recalls announced by automobile manufacturers. (2) We found automotive suppliers listed on the major U.S. stock exchanges. (3) Not all automotive suppliers sell their parts/components to every manufacturer. Therefore, for each recall from Step #1, we matched suppliers from Step #2 to the recalling manufacturer. We describe each step next.

First, following prior event study research on automotive recalls (Astvansh and Eshghi 2023; Liu, Shankar, and Yun 2017; Liu and Varki 2021), we searched Factiva, Google, *The Wall Street Journal,* and *Automotive News*, using keywords such as "product recall," "automobiles recall," "car recall," "[name of 10 largest automobile manufacturers] recalled," and "largest recalls in the automobile/car/automotive industry." This search resulted in 27 recalls of 1 million or more vehicles (see Table C1 in Web Appendix C) announced between 2010 and 2016.[2] 11 manufacturers announced these 27 recalls. Some recalls were announced on the same day or only a few days apart. Following Warren and Sorescu's (2017) recommendation, we do not remove such recalls. Concretely, we treat all recalls announced within three days of one another and affecting the same supplier as a single event (as detailed subsequently, we use a three-day [−1,1] event window), using the earliest recall as the focal event. As detailed subsequently, results are robust to excluding recall events falling within the same three-day window [−1,1].

Second, we used several sources to identify the population of automotive suppliers. We start with the list of suppliers in the SIC code 3714 ("Motor Vehicle Parts and Accessories") (Jacobs and Singhal 2020). We reviewed automobile manufacturers' websites and searched *The Wall Street Journal*, *Financial Times,* and *Automotive News* for news about manufacturer-supplier relations.

[2] We did not include recalls attributed by the news media or the NHTSA to the suppliers' defective components, such as recalls made by Takata, because such *supplier recalls* differ from *manufacturer recalls* in two characteristics (Astvansh, Suri, and Damavandi 2024; Damavandi and Astvansh 2024). First, supplier recalls induce shareholders to focus on the supplier that manufactured the defective component rather than consider the spillover from the recalling manufacturer to the dependent supplier. Therefore, unlike manufacturer recalls, supplier recalls do not elicit contagion. Second, a supplier recall likely impacts several automobile manufacturers, adversely impacting manufacturers' *production*, a phenomenon distinct from contagion in stock returns.

Publicly available third-party sources, including the PricewaterhouseCoopers' list, also indicate the largest suppliers in the automotive industry.[3] We identified which suppliers are listed on the New York Stock Exchange or the Nasdaq Stock Market. This procedure led us to 46 automotive suppliers whose common stock is publicly traded in the United States.

Third, we matched a recalling manufacturer with its suppliers by reading their annual reports and websites, as well as external sources listed in Step #2. Next, we searched Factiva for the supplier's *and* the manufacturer's names to find mentions of their relations (e.g., "Magna Ford," "Magna GM," "Magna Toyota").[4] After this matching step, we obtained 896 recall-specific distinct manufacturer-supplier dyads, which we use to measure a manufacturer's recall's impact on a supplier's shareholders' reactions. The first of our two regressions uses these 896 observations to determine whether a supplier's voluntary disclosure of customer information impacts its shareholders' reactions to a manufacturer-customer's recall. Not all suppliers disclose information about their sales revenue from manufacturer-customers (Jacobs and Singhal 2020). Therefore, our second regression (after controlling for potential sample-selection bias) uses a subsample of 223 observations to test the supplier's revenue dependence's effect on its shareholders' reactions to the manufacturer-customer's recall. Each regression controls for firm- and recall-specific covariates.

Event Study

We use the event study method (Ba et al. 2013; Hendricks and Singhal 2003) to measure a supplier's shareholders' short-term reaction to a manufacturer-customer's large recall. Specifically, we calculate a supplier's *abnormal* stock return to a manufacturer's recall event. The abnormal return is the observed/actual return minus the expected return. We use the market model to calculate the expected return in four steps (Eshghi and Astvansh 2024; Sorescu, Warren, and Ertekin 2017).

First, we regress the supplier *s*'s pre-recall return on the market pre-recall return to obtain values for $\widehat{\alpha_i}$ and $\widehat{\beta_i}$:

$$R_{s,d} = \alpha_i + \beta_s \times R_{m,d} + \varepsilon_{s,d} \quad (1)$$

$R_{s,d}$ is the stock return on the supplier *s*'s common stock on day *d*, and $R_{m,d}$ is the return of a value-weighted market index *m* on day *d*. We use a period of 240 days (ranging from 250 days before the recall to 10 days before the recall; that is [−250, −10]) to estimate the supplier's stock return (Koval, Zaefarian, and Iurkov 2024). This window is long enough to estimate the parameters $\widehat{\alpha_s}$ and $\widehat{\beta_s}$. Further, it ends 10 days before the recall, allowing us to control for the event's influence on the parameter estimates.

Second, we use $\widehat{\alpha_i}$ and $\widehat{\beta_i}$ to calculate supplier *s*'s expected return $E[R_{s,d}]$ on the day of the event:

$$E[R_{s,d}] = \widehat{\alpha_s} + \widehat{\beta_i}\, R_{m,d} \quad (2)$$

[3] For example, https://www.magna.com/docs/default-source/2017-press-releases/automotive-news-top-suppliers-6-26-2017.pdf
[4] For example, https://www.autonews.com/article/20050418/CUTAWAY/504180872/suppliers-to-the-new-toyota-aygo

Third, we calculate the abnormal return (AR) as the actual return on the day minus the expected return on the same day:

$$AR_{s,d} = R_{s,d} - E[R_{s,d}] \quad (3)$$

Fourth, the cumulative abnormal return (CAR) in the event window $[d_1,d_2]$ is

$$CAR_s[d_1, d_2] = \sum_{d_1}^{d_2} AR_{s,d} \quad (4)$$

Variables

We discuss below our study's outcome and explanatory variables. Table C2 in Web Appendix C lists all variables in our regression, their measures, and data sources.

Outcome variable*: Supplier's shareholders' reactions to a manufacturer's recall.* Consider an automobile manufacturer *m* that announces a large recall *r* on date *d* in year *y*. Further, the supplier *s* supplies automotive key/components to *m* in year *y*. We are interested in measuring supplier *s*'s shareholders' reactions to *m*'s recall *r*. As the preceding section details, we measure *s*'s shareholder reactions by *s*'s cumulative abnormal stock return (CAR) to the recall event *r*. This return is computed in the event window $[d_1,d_2]$ surrounding the recall announcement date *d*. Thus, estimating CAR requires researchers to select the number of days before the event (i.e., d_1) and the number of days after the event (i.e., d_2). Warren and Sorescu (2017) recommended selecting an event window that (1) minimizes confounding factors' influence on the supplier's stock return, (2) minimizes the chances of capturing multiple recalls clustered in time, and (3) accounts for the possibility of information leakage before the event and delayed reaction to the event. Following this recommendation, we select a three-day event window [−1,1] to measure a supplier's CAR. This window has been used in prior event studies on recalls (e.g., Davidson and Worrell 1992; Gao, Xie, Wang, and Wilbur 2015) and OM event studies on supply chain (e.g., Jacobs and Singhal 2014; Schmidt, Wuttke, Ball, and Heese 2020).

Explanatory variable #1*: Supplier's voluntary disclosure (of customer information).* U.S. law requires a publicly traded supplier to disclose in its annual report (i.e., the Form 10-K the firm files with the SEC) the sales revenue it received from each "major" customer—that is, a customer from whom the supplier received at least 10% of its total sales revenue in the focal year. The law implies that a supplier has discretion in reporting its sales revenue from "minor" customers—customers from whom it received less than 10% of its total sales revenue in the focal year (Rawlins 2008). Interestingly, the Financial Standards Accounting Board (FASB) states that the supplier "need not disclose the identity of a major customer or the amount of revenues that each segment reports from that customer" (https://fasb.org/page/ShowPdf?path=fas131.pdf&title=FAS%20131%20(AS%20ISSUED), p. 15). The inconsistency between the law and the FASB has perhaps prevented the SEC from enforcing the law (Ellis, Fee, and Thomas 2012) (see Web Appendix A).

We leverage this voluntariness to reason that following a large recall by a focal supplier's manufacturer-customer, the supplier's shareholders examine whether the supplier voluntarily disclosed customer information, specifically, (1) major customers' names and (2) sales revenue it received from nonmajor customers and the names of such customers. Assuming a manufacturer's recall in year y, we set the supplier's voluntary disclosure (of customer information) to 1 if it disclosed the customer information in year $y - 1$, and 0 otherwise.

Explanatory variable #2*: Supplier's revenue dependence* is the ratio of the focal supplier s's sales revenue from the recalling manufacturer-customer in year $y - 1$ divided by the supplier's total sales revenue in $y - 1$ (Jacobs and Singhal 2020; Jacobs, Singhal, and Zhan 2022).

Explanatory variable #3: *Recall size* is the natural logarithm of the number of vehicles affected by the focal recall (e.g., Eilert, Jayachandran, Kalaignanam, and Swartz 2017; Gao, Xie, Wang, and Wilbur 2015).

Explanatory variable #4: *Recall news volume* is the number of news articles specific to the focal recall and published in the following six news publishers: *The Wall Street Journal*, *USA Today*, The *New York Times*, *Washington Post*, *New York Post*, and *Financial Times* (Astvansh, Wang, and Shi 2022; Gao, Xie, Wang, and Wilbur 2015).

Explanatory variable #5: *Recall news sentiment* is the sum of the sentiment scores of recall-specific news articles published by the six news publishers listed above. We compute each news article's each word's sentiment using lexicons that rate the sentiment on −1 to +1 scale. Thus, higher values indicate more positive sentiment (Astvansh, Wang, and Shi 2022). More concretely, following prior marketing (e.g., Mukherjee, Dutta, and De Bruyn 2022) and OM (e.g., Gour, Aggarwal, and Kumar 2022) research, we use the R-package *Syuzhet* with the get_sentiment function, which relies on four lexicons that each capture different aspects of sentiment to ensure comprehensiveness: *Syuzhet*, AFINN, Bing, and NRC. Recall news sentiment is the sum of the sentiment scores of all words within the text of the articles announcing the recall. We ensure consistency across recalls by focusing on the three most important (ranked by Factiva) articles.

Explanatory variable #6: *Customer harm* equals 1 if the news articles report that the defect caused injuries and/or death to drivers, passengers, and the public (e.g., Eilert, Jayachandran, Kalaignanam, and Swartz 2017; Javadinia, Gill, and Jayachandran 2024).

Explanatory variable #7: *Software recall* equals 1 if the recall relates to a software issue, and 0 otherwise (Darby, Ketchen, Ball, and Mukherjee 2023; Thirumalai and Sinha 2011).

Covariates: Our regression controls for nine supplier-, five recall-, and two manufacturer-specific variables that may impact shareholders' reactions to the supplier (see Table C2). Table C3 in Web Appendix C provides reasons for including these covariates.

Regression Specification

We estimate Equations 5 and 6 below.

$$
\begin{aligned}
&Supplier's\ shareholders'\ reaction_{s,r[-1,1]} = \\
&\quad \alpha_0 \\
&\quad + \alpha_1\ Supplier's\ voluntary\ disclosure_s + \alpha_2\ Recall\ size_r + \alpha_3 Recall\ news\ volume_r \\
&\quad + \alpha_4\ Recall\ news\ sentiment_r + \alpha_5\ Customer\ harm_r + \alpha_6\ Software\ recall_r \\
&\quad + \sum \alpha_{7-15}\ Supplier - specific\ \ covariates_s \\
&\qquad\qquad + \sum \alpha_{16-19}\ Recall - specific\ \ covariates_r \\
&\qquad\qquad + \sum \alpha_{20-22}\ Manufacturer - specific\ covariates_m + \Theta_t + \varepsilon_{s,r}
\end{aligned}
\tag{5}
$$

α_0 is the intercept; $\sum \alpha_{7-15}, \sum \alpha_{16-19}, \sum \alpha_{20-22}$ are coefficients for supplier *s*, recall *r*, and manufacturer *m* specific covariates, respectively; Θ_t is a vector of dummy variables for year; and $\varepsilon_{r,s}$ is random error.

$$
\begin{aligned}
&Supplier's\ shareholders'\ reaction_{s,r[-1,1]} = \\
&\delta_0 + \delta_1\ Supplier's\ revenue\ dependence_s + \delta_2\ Recall\ size_r + \delta_3 Recall\ news\ volume_r \\
&\quad + \delta_4 Recall\ news\ sentiment_r + \delta_5\ Physical\ harm_r + \delta_6\ Software\ defect_r \\
&\quad + \sum \delta_{7-15}\ Supplier - specific\ \ covariates_s \\
&\qquad\qquad + \sum \delta_{16-19}\ Recall - specific\ \ covariates_r \\
&\qquad\qquad + \sum \delta_{20-22}\ Manufacturer - specific\ covariates_m + \Theta_t + \eta_{s,r}
\end{aligned}
\tag{6}
$$

δ_0 is the intercept; $\sum \delta_{7-15}, \sum \delta_{16-19}, \sum \delta_{20-22}$ are coefficients of supplier *s*, recall *r*, and manufacturer *m* level covariates, respectively; Θ_t is a vector of dummy variables for year; and $\eta_{r,s}$ is the random error.

Multiple suppliers can supply to a manufacturer. Therefore, we estimate supplier-clustered standard errors. This clustering estimates coefficients that are robust to (1) within-supplier correlations (i.e., equivalent to random effects) and (2) heteroscedasticity (Eilert et al. 2017).

Supplier's Disclosure Decision's Potential Endogeneity

A supplier firm strategically decides whether to disclose customer information. Unobserved managerial characteristics (e.g., disclosure orientation) can be correlated with this decision and might directly impact shareholders' reactions. Omitting these characteristics makes the disclosure decision plausibly endogenous to our specification of shareholders' reactions. We control for the disclosure decision's endogeneity using the control function (CF) method (Lu et al. 2018; Petrin and Train 2010) because the "approach is better suited for addressing endogeneity for a non-continuous (independent) variable" (Papies, Ebbes, and Van Heerde 2017, p. 589). We also present the estimates without endogeneity control.

The first stage of the CF method uses the logit model to regress the disclosure decision on covariates listed in Table C2. The first-stage logit regression also includes a variable , which is excluded from the second-stage regression (conceptually, an instrument): a binary variable that equals 1 if a prominent U.S. news publisher reported on the focal supplier's business in the year of the disclosure and 0 otherwise. We reason that our excluded variable is likely relevant—that is, it is

associated with the potentially endogenous variable of disclosure decision. Shareholders lack information about a firm (a supplier, in our context). A prominent news publisher's mentions of the firm attenuate the shareholders' information asymmetry (e.g., Liu, Shankar, and Yun 2017; Noack, Miller, and Smith 2019). Therefore, all else equal, a supplier covered by a prominent news organization has less incentive to reduce its shareholders' information asymmetry by disclosing customer information (Merton 1987). Conversely, a supplier that lacks prominent news media coverage has more reason to disclose customer information to reduce shareholders' information asymmetry (Tourani-Rad and Kirkby 2005). Therefore, we expect prominent news coverage to be negatively associated with the supplier's decision to disclose customer information voluntarily. Further, we reason that our instrument meets the exclusion restriction—that is, it is uncorrelated with unobserved determinants of the shareholders' reactions. We reason so because the supplier's prominent media coverage occurred before the recall. Thus, the efficient market hypothesis (Malkiel and Fama 1970) suggests that the coverage is *known* to the supplier's shareholders and factored into its stock price before the recall announcement.

Potential Selection Bias in the Subsample of Suppliers that Disclosed Revenue Dependence on the Recalling Manufacturer

Only a subsample of suppliers disclosed revenue dependence on the recalling manufacturer. Therefore, the subsample may be selective, thus biasing the estimated coefficients (Wooldridge 2010). We control for this potential bias by estimating Heckman's (1979) two-stage selection model. The first-stage model is a binary probit regression of whether the focal supplier s reported the sales revenue it received from the recalling manufacturer m in year $y - 1$. The second stage explains the supplier's shareholders' reactions, including the inverse Mills ratio (λ), computed using the regression coefficients from the first stage.

The first-stage regression requires an excluded variable, which must impact the supplier's decision variable but not the outcome variable of shareholders' reactions. Our exclusion variable is an indicator that equals 1 if the supplier is headquartered in the United States or Canada, and 0 otherwise. Prior research has reasoned that the U.S. and Canadian stock markets are more mature than other countries'. Therefore, shareholders scrutinize firms headquartered in these two countries less than they scrutinize firms headquartered elsewhere (Nahata, Hazarika, and Tandon 2014; Ling, Wang, and Zhou 2021). By extension, suppliers headquartered outside the United States and Canada have a greater incentive to disclose their customer revenue, limiting shareholders' perceived information disadvantage and promoting market transparency (Cashman et al. 2019; Chakrabarti, Gupta-Mukherjee, and Jayaraman 2009). Therefore, the supplier's headquarters location should be associated with its decision to disclose the sales revenue it received from a manufacturer-customer, thus meeting the relevance criterion. Further, the headquarters' location should not be associated with the error term of the stock returns model for two reasons. First, relocating headquarters from one country to another is a resource-demanding process. Thus, managers cannot easily make such a

decision and implement it. Second, the headquarters location should not be of primary concern for shareholders during recalls. Thus, on average, a manufacturer's recall should not cause shareholders to assess the supplier's future performance variation based on its headquarters' country. We present results with and without Heckman's correction.

RESULTS

Model-Free Results

Table C4 (Web Appendix C) reports our variables' mean and standard deviation (SD). It also reports Pearson correlation coefficients between key variables.

The average value of suppliers' cumulative abnormal stock returns to a manufacturer-customer's recall is 0.40% on the day of the announcement ($t = -3.181$, $p < .01$). The insight is that the supplier's shareholders react punitively to a manufacturer-customer's recall. Shareholders' reactions are negative in the following five event windows: ([0,1], [−1,0], [−1,1], [−2,2], and [−5,5]). They are significantly different from zero for [0,1] (−0.39, $t = -2.219$, $p < .05$) and [−1,0] (−0.33, $t = -1.858$, $p < .10$), suggesting significant contagion (or negative spillover) from the manufacturer to its supplier. These results support the efficient market hypothesis as suppliers' shareholders react instantaneously to new and diagnostic information. In addition, the results suggest two key findings: (1) information leakage occurs a day before the manufacturer-customer announces the recall, and (2) shareholders continue to react a day after the announcement.

Supplier's Voluntary Disclosure of Customer Information → Suppliers' CAR to a Manufacturer's Recall

Table 1's Column I reports the estimates from the regression that assumes the supplier's customer information disclosure is exogenous. Columns II and III present estimates from the control function method, where we control for the disclosure's potential endogeneity. Column II shows that being covered (vs. not) by a prominent U.S. news publisher is negatively associated with the supplier's voluntary disclosure of customer information (Column II: $b = -0.747$, $p < .05$). This finding is consistent with intuition and logic that coverage by a prominent news publisher attenuates the supplier's incentive to attenuate shareholder's information disadvantage by disclosing customer information. Thus, our instrument likely meets the relevance criterion.

Columns I and III show that the supplier's voluntary disclosure positive affects $CAR_{[-1,1]}$ (Column I: $b_{Supplier's\ voluntary\ disclosure} = 0.857$ $p < .05$; Column III: $b_{Supplier's\ voluntary\ disclosure} = 1.701$ $p < .01$). In other words, disclosure attenuates shareholders' punitive reactions (i.e., as we reported earlier, a manufacturer recall lowers its supplier's shareholder value by 0.40% on the day of the recall, on average). The finding is consistent with our logic that the supplier's voluntary disclosure of customer information is the shareholders' screen for the recall's implications for the supplier's cash flows in the short term.

Next, we focus on five recall-specific regressors, which proxy recall severity and may thus serve as a shareholder screen. The coefficient estimates in Columns I and III carry the same sign and

are similar in magnitude. Therefore, we report the estimates for Column III. Consistent with our intuition and prior research (e.g., Liu, Shankar, and Yun 2017), recall size ($b_{Recall\ size} = b = -.792\ p < .01$) and recall news volume ($b_{Recall\ news\ volume} = -.432\ p < .01$) are negatively associated with shareholder reactions. However, contrary to our expectations and prior research (e.g., Noack, Miller, and Smith 2019), recall news sentiment ($b_{Recalls\ news\ sentiment} = -.133\ p < .01$) is negatively associated with shareholder reactions. In other words, the more positive the news, the more negative the shareholder reaction. We turned to signaling theory and recall literature to make sense of the seemingly counterintuitive negative sign. We found two explanations. Signaling theory suggests that signal inconsistency—e.g., media using positive language to convey negative news—can confuse shareholders, increasing uncertainty and punitive reactions (Connelly et al. 2011). Product recall literature has revealed that news publishers may use milder language when reporting large recalls, thus maintaining relations with their corporate advertisers (Beattie, Durante, Knight, and Sen 2021). Shareholders may perceive favorable coverage of a large recall as an attempt to obscure negative news, reinforcing signal inconsistency and raising negative reactions.

Additionally, while customer harm exhibits the expected negative coefficient, the association does not reach statistical significance ($b_{Customer\ harm} = -.657\ p > .1$), a finding consistent with prior research (Eilert, Jayachandran, Kalaignanam, and Swartz 2017). Finally, shareholders react less negatively to a software (vs. nonsoftware) recall (Column I: $b_{Software\ recall} = 2.375\ p < .01$), suggesting that shareholders are less punitive toward software defects, which can be addressed by less costly over-the-internet changes (Darby, Ketchen, Ball, and Mukherjee 2023). Collectively, these results suggest that contextual variables (i.e., recall variables in our case) shape the supplier's shareholders' perceived uncertainty, thus shaping their reactions. These characteristics are outside the supplier's managerial control. However, the evidence would help managers understand the contextual variables' explanatory value in determining shareholder reactions.

Table 1: Supplier's Voluntary Disclosure of Customer Information → Shareholders' Reactions to a Manufacturer-Customer's Product Recall

	DV: $CAR_{[-1,1]}$	DV: Supplier's voluntary disclosure: Yes vs. no	DV: $CAR_{[-1,1]}$
	I	II	III
	No endogeneity correction	Two-stage Control Function	
		First-stage	Second-stage
Supplier's voluntary disclosure: Yes vs. no	0.857**		1.701***
	(0.322)		(0.531)
Recall size	-0.800***	0.0225	-0.792***
	(0.240)	(0.271)	(0.238)
Recall news volume	-0.433***	-0.0442	-0.432***
	(0.0752)	(0.108)	(0.112)
Recall news sentiment	-0.132***	0.0180	-0.133***
	(0.0338)	(0.0411)	(0.0369)
Customer harm	-0.662	0.133	-0.657
	(0.509)	(0.518)	(0.465)
Software recall	2.280**	-1.287	2.375***
	(1.022)	(1.558)	(0.890)
Supplier's customer breadth	-0.148	1.575***	-0.219

	(0.127)	(0.291)	(0.201)
Supplier's customer depth	0.171**	-0.0491	0.181*
	(0.0800)	(0.0988)	(0.0997)
Supplier's customer equity	3.109*	6.346***	2.766
	(1.747)	(2.104)	(2.469)
Supplier's R&D	2.207	23.11***	0.809
	(3.293)	(4.285)	(3.845)
Supplier's liquidity	0.409**	-1.321***	0.499***
	(0.163)	(0.244)	(0.182)
Supplier's age	0.0109*	-0.104***	0.0160**
	(0.00594)	(0.0129)	(0.00662)
Supplier's profitability	-0.397	12.39***	-1.579
	(1.321)	(1.915)	(1.978)
Supplier's size	0.315***	-0.616***	0.357***
	(0.110)	(0.123)	(0.117)
Supplier's gross margin	-1.782	-1.950	-1.766
	(1.126)	(2.296)	(1.316)
Recall scope: global vs. US	-0.796	0.0146	-0.800
	(0.689)	(0.609)	(0.644)
Recall initiator: government vs. manufacturer	-0.575	-0.110	-0.573
	(0.514)	(0.389)	(0.453)
Recall initiator: not available vs. manufacturer	-0.0674	0.0497	-0.0805
	(0.606)	(0.582)	(0.610)
Clustered recall	1.104	-0.285	1.075
	(0.754)	(1.005)	(0.838)
Additional recall	0.121	0.190	0.124
	(0.492)	(0.510)	(0.450)
Manufacturer's gross margin	-4.033	-2.280	-3.648
	(2.977)	(4.741)	(4.237)
Region of manufacturer's headquarters:	1.594***	0.178	1.587***
Asia vs. the United States	(0.424)	(0.508)	(0.405)
Region of manufacturer's headquarters:	1.387	-0.354	1.386
Europe vs. the United States	(0.956)	(1.068)	(0.949)
Whether a prominent U.S. news publisher covered the supplier (excluded variable for Heckman's first-stage regression)		-0.747**	
		(0.302)	
Control function			-0.442**
			(0.184)
Constant	-1.677***	-3.206***	-1.866***
	(0.480)	(0.671)	(0.559)
Observations	896	896	896
Year FE	YES	YES	YES
Adjusted (Pseudo) R-squared	0.071	0.484	0.073

*** p<0.01, ** p<0.05, * p<0.1.

Note: Standard errors (SEs) are reported in parentheses. The regression for Column I uses SEs clustered by suppliers. The regressions for Columns II and III (i.e., Control function) use SEs bootstrapped 500 times.

Supplier's Revenue Dependence on the Recalling Manufacturer-Customer → Supplier's CAR to the Manufacturer's Recall

Table 2 reports how the supplier's revenue dependence on the recalling manufacturer-customer impacts its shareholders' reactions to the manufacturer's recall. Column I displays the results *without* the Heckman correction term's inclusion. Results suggest that the higher the supplier's dependence on the recalling manufacturer, the more negative the supplier's shareholders' reactions to the recall ($b_{Revenue\ dependence} = -0.041$, $p < .05$).

Column II presents the estimates from the first-stage regression of Heckman's model. Consistent with our expectation, a supplier headquartered in the United States or Canada is less likely to disclose its dependence on the recalling manufacturer than a counterpart headquartered in other countries ($b_{HQ\ in\ US/Canada} = -0.387$, $p = .052$). Thus, the excluded variable likely meets the relevance criterion. Statistical evidence suggests that the variable may also meet the exclusion restriction. Specifically, the pseudo-R^2 of the first-stage regression is 43%, well above the 24% benchmark obtained by Certo et al.'s (2016) simulations to define a strong exclusion restriction. Additionally, the correlation coefficient between revenue dependence and the inverse Mills ratio (λ) is .05, exceeding Certo et al.'s (2016) benchmark of .30. In other words, the power of the test of λ is greater as the correlation between λ and the potentially endogenous explanatory variable is smaller. Despite a smaller subsample, the recall variables' coefficients are similar to those in Table 1.

Table 2: Supplier's Revenue Dependence on Manufacturer → Shareholders' Reactions to a Manufacturer-Customer's Product Recall

	DV: $CAR_{[-1,1]}$	DV: Revenue dependence observed	DV: $CAR_{[-1,1]}$
	I	II	III
		Two-stage Heckman model	
	Without correction for sample selection	First stage of Heckman's model	Second stage of Heckman's model
Supplier's revenue dependence	-0.0412**		-0.0414*
	(0.0193)		(0.0243)
Recall size	-1.000**	0.0286	-1.015
	(0.463)	(0.167)	(0.681)
Recall news volume	-0.752***	0.00558	-0.775***
	(0.188)	(0.0618)	(0.237)
Recall news sentiment	-0.168*	-0.0121	-0.140
	(0.0842)	(0.0271)	(0.112)
Customer harm	-1.027	0.235	-1.337
	(1.528)	(0.306)	(1.371)
Software recall	3.490*	-0.213	3.822**
	(1.753)	(1.694)	(1.805)
Supplier's customer breadth	-0.224	0.823***	-1.202
	(0.386)	(0.144)	(0.876)
Supplier's customer depth	0.0976	0.468***	-0.478
	(0.109)	(0.0530)	(0.477)
Supplier's customer equity	-9.847*	0.362	-10.86*
	(5.471)	(1.105)	(5.941)
Supplier's R&D	3.663	2.909	-2.166
	(7.524)	(2.117)	(11.89)
Supplier's liquidity	0.266	-0.272***	0.539
	(0.222)	(0.104)	(0.399)
Supplier's age	0.000717	-0.0104**	0.0225
	(0.00919)	(0.00449)	(0.0238)
Supplier's profitability	8.899***	1.876**	6.026
	(2.922)	(0.888)	(6.334)
Supplier's size	-0.0850	-0.167***	0.0962
	(0.165)	(0.0579)	(0.291)
Supplier's gross margin	-9.002	-1.041	-7.067
	(5.528)	(1.017)	(6.790)
Recall scope: global vs. US	-1.251	0.263	-1.456
	(0.789)	(0.344)	(0.939)
Recall initiator: government vs. manufacturer	0.450	-0.174	0.638

	(0.908)	(0.223)	(0.921)
Recall initiator: not available vs. manufacturer	0.265	-0.605*	0.940
	(1.410)	(0.362)	(1.404)
Clustered recall	0.0824	0.594	-0.757
	(1.755)	(0.557)	(2.440)
Additional recall	0.885	-0.218	1.394
	(1.628)	(0.330)	(1.520)
Manufacturer's gross margin	19.91	-4.197	24.55
	(15.86)	(2.924)	(18.80)
Region of manufacturer's headquarters:	3.152***	-0.926***	4.391***
Asia vs. the United States	(0.920)	(0.308)	(1.391)
Region of manufacturer's headquarters:	-0.998	0.0365	-1.116
Europe vs. the United States	(2.542)	(0.630)	(3.214)
Supplier's headquarters: North America (vs. Rest of the World)		-0.387*	
		(0.199)	
Inverse Mills ratio			-2.414
			(1.860)
Constant	-2.063	-0.619	1.255
	(1.314)	(0.393)	(2.967)
Year FE	YES	YES	YES
Observations	223	896 (223 selected)	223
Fit statistics	R-squared 0.272	Pseudo-R^2 = 0.428	Wald Chi^2 test = 64.08 (p<0.01)

*** p<0.01, ** p<0.05, * p<0.1

Note: Standard errors (SEs) are reported in parentheses. The regression for Column I uses SEs clustered by suppliers. The regressions for Columns II and III (i.e., Heckman's two-stage model) use SEs bootstrapped 500 times.

Insights from Covariates' Coefficients

The supplier's customer depth's coefficient is positive and significant in the full-sample regression (Table 1: $b_{Supplier's\ customer\ depth} = 0.181$, $p < .1$) but insignificant in the subsample regression (Table 2, $b_{Supplier's\ customer\ depth} = 0.098$, $p > .1$). These findings are consistent with the customer portfolio management literature, which stipulates that a deeper portfolio reduces the supplier's demand uncertainty, assuaging shareholders' punitive reactions (Cohen and Li 2020; Korcan and Patatoukas 2016; Leung and Sun 2021). Similarly, supplier liquidity's and size's coefficients are positive and significant in the full sample ($b_{Supplier's\ liquidity} = 0.409$ $p < .05$; $b_{Supplier's\ size} = 0.315$, $p < .01$) but insignificant in the subsample ($b_{Supplier's\ liquidity} = 0.266$, $p > .01$ $b_{Supplier's\ size} = -0.085$, $p > .1$). A supplier's liquid assets could help limit the contagion. In contrast, larger suppliers are likely to have more resources to withstand the adverse effects of recalls and more opportunities to find alternative sources of revenue, attenuating shareholders' negative reactions.

Customer depth's, liquidity's, and size's coefficients' significance in the full sample and insignificance in the subsample are consistent with screening theory, which posits that screens vary according to their strength (Gulati and Higgins 2003). In our context, the supplier's revenue dependence on the manufacturer-customer is a strong screen for the supplier's shareholders, overshadowing weaker ones. Thus, shareholders strongly consider alternative screens, such as customer depth, liquidity, and size, when the revenue dependence screen is unobservable.

Robustness Tests

We undertake six robustness tests on the full sample and the subsample. (1) We treat year as a continuous variable because variance inflation factors in the full model exceed 10, mostly due to the correlation between year-fixed effects and some regressors (in that model, the maximum VIF is 5.1). (2) We include the manufacturer's reputation and market share covariates and use year as a continuous variable because adding two new covariates with year-fixed effects amplifies multicollinearity. (3) We measure abnormal return using the Fama-French model (Fama and French 1993) instead of the market model. (4) We Winsorize the outcome variable at the 5th percentile to limit the influence of extreme values. (5) We exclude clustered recall events within the three-day window [−1,1]. (6) We sample suppliers headquartered in the United States and Canada. The sign, magnitude, and significance levels of the estimated coefficients of the alternative samples and/or regressions are consistent with those reported in Tables 1 and 2. Columns 1.1-6.2 in Table D1 in Web Appendix D present the estimates.

Because the endogeneity correction term for the supplier's voluntary disclosure was significant (Table 1, Column III), we repeated all robustness tests related to the supplier's voluntary disclosure variable with the endogeneity correction, which yielded similar results (Table D2 in Web Appendix D).

DISCUSSION

Manufacturer-supplier relations are intertwined, particularly in product quality (Barnett and King 2008; Hertzel, Li, Officer, and Rodgers 2008; Yu, Sengul, and Lester 2008). Therefore, intuition suggests that a manufacturer-customer's product recall—particularly, a large one—can raise uncertainty about the demand for the manufacturer's products and, by extension, the supplier's products (Freedman, Kearney, and Lederman 2012; Liu and Varki 2021; Mukherjee et al. 2022; Zavyalova et al. 2012). The supplier's shareholders experience this uncertainty and bid down the supplier's stock price. Our post-hoc analysis reveals that a manufacturer's large recall can erase 1.15% of a supplier's shareholder value,[5] amounting to US$23 million for an average supplier in our sample. Further, an average manufacturer in our sample contracts with 33 suppliers, which amounts to a substantial loss in suppliers' cumulative shareholder value. The manufacturer-customer's recall's negative impact on a supplier's shareholder value (i.e., contagion, or negative spillover) constitutes the starting point of our research. We invoke screening theory to propose the supplier's prior voluntary disclosure of customer information and recall contextual variables as screens that may moderate shareholders' uncertainty and, by extension, their reactions.

[5] This calculation is based on the average return on the day of the recall (−0.4%), multiplied by the average number of recalls per year (3.85) and the probability (0.75) that a supplier will be affected (i.e., not every industry supplier delivers product to every industry manufacturer).

Theoretical Contributions

Prior research on supply-chain (or more specifically, customer-to-supplier) contagion (see the revised e-companion's new Table B1 in Web Appendix B) has shown that customer-related negative information can adversely impact a supplier's shareholder value. A manufacturer's decision to recall defective products is a notable omission in the literature. One can argue that the recall is "just another" negative information and thus theoretically identical to other customer-related negative information. However, the manufacturer's recall is an admission of low product quality, which is customer-related negative information directly related to the firm's supply-chain management. More importantly, recall information is substantively distinct from negative information about the manufacturer's accounting, finance, or management failure (e.g., low earnings, bankruptcy filing, and misconduct). As a result, one cannot confidently extrapolate prior research findings to contagion in the recall context. We show that a manufacturer's recall induces a drop in its supplier's shareholder value. This finding contributes to the supply-chain contagion literature by *replicating* the contagion (or negative spillover) effect in the OM-relevant context of a customer's admission of a product-quality defect. Although managerially relevant, we do *not* frame this finding as a contribution because prior research has shown contagion, albeit in non-recall contexts.

We offer contributions to (1) the supply-chain contagion literature (see Table B1), (2) screening theory, and (3) the customer information disclosure literature.

First, the supply-chain contagion literature (see Table B1) has examined the contagion's presence and explained heterogeneity by managerially *uncontrollable* variables (e.g., headquarters' country/region) (e.g., Hendricks, Jacobs, and Singhal 2020; Qiu, Xu, Yeung, and Zeng 2024). We contribute to this literature by demonstrating that the supplier's prior customer-related disclosures and recall contextual variables can mitigate shareholders' perceived uncertainty, influencing their punitive reaction to the manufacturer's recall (Eckert 2020). Interestingly, the supplier's revenue dependence on the recalling customer, disclosed as part of the superset of customer information, aggravates the reaction. Thus, we extend the contagion literature by demonstrating that managerially controllable and contextual variables can influence contagion.

Second, prior research on screening theory (Bergh, Peruffo, Chiu, Connelly, and Hitt 2020; Connelly, Shi, Cheng, and Yin 2021; Sanders and Boivie 2004) has implicitly assumed that a less-informed decision-maker (e.g., the supplier's shareholders in our context) undertakes a single-stage screening to alleviate their uncertainty and make their decision. We extend the screening theory by suggesting that shareholders' preferred screen may be unavailable, leading them to use a two-stage screening. In our recall context, the ideal (and obvious) screen is the supplier's revenue dependence on the recalling manufacturer. However, the supplier may not have disclosed this information in its most recent annual report. This nondisclosure is legally compliant and arguably preferred because it prevents the supplier from disclosing proprietary information to its rivals and thus avoids proprietary

costs (Cai, Teng, and Xin 2022; Ellis, Fee, and Thomas 2012; He, Chen, and Chan 2022). Therefore, shareholders undertake a two-stage screening. First, they check whether the supplier voluntarily disclosed customer information in the most recent annual report. The supplier's transparency in revealing customer information may attenuate shareholders' perceived uncertainty about the supplier's customer relations, mitigating their punitive reaction. Second, if the supplier disclosed its revenue dependence on the recalling manufacturer-customer, the dependence amplifies shareholders' demand uncertainty, aggravating their punitive reaction. We reason that this two-stage procedure is a novel addition to screening theory.

Third, customer information disclosure literature posits two-sided arguments on whether shareholders value this disclosure (Bayer, Tuli, and Skiera 2017; Ellis, Fee, and Thomas 2012; Xu, Cai, and Zhang 2024). On the one hand, the disclosure signals the firm's transparency, boosting shareholder value. On the other hand, it can allow the firm's rivals to poach its customers, impeding shareholder value. We contribute to this literature by documenting disclosure's asymmetrical effects in the substantive context of the customer's recall impacting the supplier's shareholder value. Disclosing "general" customer information helps limit shareholder-value loss. In contrast, disclosing "specific" customer information (i.e., revenue dependence on the recalling manufacturer) amplifies shareholder-value loss. Thus, our findings generalize the two-sided arguments, expanding the disclosure's benefits and costs when demand uncertainty is high (Cohen and Li 2020; Fang, Palmatier, and Grewal 2011; Korcan and Patatoukas 2016; Patatoukas 2012).

Managerial Implications

Our findings alert supplier firm managers that a manufacturer-customer's recall can induce shareholders' punitive reaction, reflected in a drop in its shareholder value. More importantly, we reveal several factors that can mitigate or aggravate this contagion.

We suggest managers consider the contagion effect of a customer's recall when deciding whether to disclose customer information. The disclosure can attenuate contagion by revealing the supplier's alternative sources of revenue. At the same time, disclosure may aggravate contagion by revealing the extent of revenue in jeopardy. Notably, nondisclosure is not necessarily a panacea. For example, if the supplier's performance drops due to a customer's large recall, the absence of information about the supplier's revenue dependence on the customer may induce shareholder distrust. They may fear the worst-case cash flow drop and impose the highest penalty on the supplier. Disclosure's two-sided implications highlight the delicate balance managers must strike between transparency and anticipatory management of recall risks, especially in industries characterized by frequent recalls—e.g., an automotive supplier can expect about three large-scale customer recalls each year. We performed a post hoc analysis to empirically determine when a voluntary disclosure strategy may be a successful strategy to prevent contagion. Results show that if a supplier's customers account for less than 21% of its annual sales revenue, it should voluntarily disclose its customer relationship information. Conversely, if major customers account for 21% or more of the supplier's annual sales

revenue, disclosure's aggravation outweighs mitigation, suggesting that the supplier is better off not disclosing the relationships.

Additionally, when contagion looms, the supplier may fare better by leveraging several firm- and recall-specific characteristics. Specifically, suppliers that are larger, older, have more liquidity, and maintain better customer relations are less susceptible to contagion. By contrast, larger recalls and those covered broadly and positively by news publishers exacerbate contagion. Recalls triggered by software versus nonsoftware defects yield milder contagion. Thus, managers can proactively mitigate contagion by improving financial flexibility and strengthening customer ties. If these characteristics provide sufficient mitigation, managers may evaluate whether the disclosure's costs (i.e., revealing dependence) dominate the reduced benefits (i.e., transparency about alternative revenue sources). Lastly, empirically, recall characteristics' mitigation is more potent when the firm does not disclose customer information than when it does—recall characteristics' effects are stronger in Model 1, than in Model 2—further highlighting the usefulness of knowing which characteristics blunt large recalls' effects if firms decide not to be transparent about customer information.

Limitations and Future Research

Our research provides initial proof-of-concept evidence that suppliers can, to some extent, mitigate a customer recall's negative effect. We hope our findings serve as a basis to generate hypotheses that can be formally tested in the future. In addition to the need to establish the current findings more firmly, we propose that further research could examine three specific extensions. First, we provide evidence from the U.S. automotive industry. Future research should consider checking our findings' generalizability to (1) other industries (e.g., such as food and medical devices), and (2) other countries where institutions and regulations differ from those in the United States (e.g., China). Second, we focus on the *upstream* (i.e., customer-to-supplier) contagion. Future research could test the presence of downstream contagion. For example, when Takata Corporation announced its airbag recall, how did Takata's customers' shareholders react? We posit that a mechanism different from our proposed mechanism (of demand uncertainty) might explain the answer. Third, future research could investigate whether contagion occurs and how it can be mitigated for other customer-related negative events, such as production halts and employee strikes (Astvansh, Duffek, and Eisingerich 2023; Astvansh and Simpson 2025). In summary, our research represents a valuable first step at the intersection of manufacturer-specific operational failures and manufacturer-supplier relations, providing avenues for future research.

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Product Recall Contagion in the Supply Chain

E-COMPANION

WEB APPENDIX A: THE U.S. LAW AND FASB STANDARD FOR DISCLOSING MAJOR CUSTOMERS' INFORMATION

The U.S. Code for Federal Regulations (CFR) Title 17's Section 229.101 (c) states, "The name of any customer and its relationship, if any, with the registrant or its subsidiaries shall be disclosed if sales to the customer by one or more segments are made in an aggregate amount equal to 10 percent or more of the registrant's consolidated revenues and the loss of such customer would have a material adverse effect on the registrant and its subsidiaries taken as a whole. The names of other customers may be included, unless in the particular case the effect of including the names would be misleading" (https://www.govinfo.gov/content/pkg/CFR-2011-title17-vol2/pdf/CFR-2011-title17-vol2-sec229-101.pdf, p. 354). The law defines such a customer as "major" and frames the supplier as "dependent" on the customer (see p. 357).

The Financial and Accounting Standards Board [FASB]) Standard No. 131 (https://fasb.org/page/ShowPdf?path=fas131.pdf&title=FAS%20131%20(AS%20ISSUED)) states, "The enterprise need not disclose the identity of a major customer or the amount of revenues that each segment reports from that customer" (p. 15). Therefore, unlike the law, the standards position the disclosure of the revenue from and the name of a major customer as discretionary.

In practice, many firms report revenue from major customers (thus, these customers are "major") but do not disclose their names (Ellis, Fee, and Thomas 2012). Importantly, the SEC has never conducted enforcement actions in response to such law violations. Interestingly, some firms disclose names of nonmajor customers as well, suggesting the opposite extreme of voluntary behavior. Our research leverages this voluntariness in firm disclosure of customer names.

WEB APPENDIX B: LITERATURE

Table B1: Representative Multidisciplinary Literature on a Customer Firm-Related Negative Information Hurting its Supplier's Outcomes (i.e., Customer-to-Supplier Spillover)

Note: We searched Google Scholar for articles that mention "spillover" or "contagion" in their titles. We summarize articles that measure negative supplier outcomes of a customer's negative information—i.e., negative spillover or contagion.

Citation	**Negative information/event type**	**Supplier actions that aggravate shareholders' reactions**	**Supplier actions that mitigate shareholders' reactions**	**Event characteristics**	**Findings**
This study	Manufacturer-customer's product recall	Revenue dependence on the customer	Customer relationship disclosure, customer depth, equity	Recall size, News volume, news sentiment, customer harm, and software recall	A customer's large product recall lowers an uninvolved supplier's abnormal stock return.
Barth, Eckert, Gatzert, and Scholz (2019)	Manufacturer's admission of ethical misconduct	None	None	None	Volkswagen's public admission of manipulating its vehicles' emissions values lowered its European suppliers' abnormal stock return and their abnormal bond return. No effect for non-European suppliers' stock return or bond return.
Hendricks, Jacobs, and Singhal (2020)	Earthquake	None	None	None	The Great East Japan Earthquake (GEJE) lowered affected firms' suppliers' stock return by 2.85% in the [0,2] window (see Table 4's Panel C).
Hertzel, Li, Officer, and Rodgers (2008)	Chapter 11 bankruptcy filing	None	None	None	A firm's Chapter 11 bankruptcy filing causes an average drop of 1.94% in its dependent supplier's stock return.
Jacobs and Singhal (2020)	Manufacturer's admission of ethical misconduct	Revenue dependence	None	None	Volkswagen's public admission of manipulating its vehicles' emissions values caused an average drop of 2.69% in its tier-1 suppliers' abnormal stock returns. The admission did not impact Volkswagen's tier-2 suppliers' stock returns.
Kolay, Lemmon, and Tashjian (2016)	A firm's Chapter 11 bankruptcy filing	None	None	None	The authors measure the probability of the firm emerging from bankruptcy and relate this bankruptcy to the firm's dependent supplier's cumulative abnormal stock return to the firm's bankruptcy filing announcement. A financially distressed firm's, but not its economically distressed peer's,

					bankruptcy filing lowers its dependent supplier's abnormal stock returns by 7.3%.
Li, He, and Chan (2021)	A customer firm's textual disclosure of risk information in its annual report	None	None	None	A firm's qualitative/textual disclosure of its risk causes a drop of .5074% in its dependent supplier's abnormal stock return.
Pandit, Wasley, and Chan (2011)	Customer's earnings announcement	Revenue dependence	None	Informativeness and valence of the customer's announcement	A customer's abnormal stock returns to earnings announcement are positively associated with its supplier's abnormal returns.
Qiu, Xu, Yeung, and Zeng (2024)	Stock price crash	Customer importance	None	Whether the crash-inducing incident is operational or financial	A customer firm's stock price crash is positively associated with its dependent supplier's stock price crash.
Wang, Xiong, Cheng, and Lam (2024)	Corruption in supply-contract procurement	None	None	None	A law court's verdict announcing a firm of corruption causes a drop of 1.08% in its supplier's abnormal stock return.

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WEB APPENDIX C: SAMPLE

Table C1: Sampled 27 Recalls

Note: Recalls with the same ID took place within a three-day period. We merged them in the main analysis—we included the "Clustered recall" dummy variable as a control—but excluded them in one of the robustness checks. Our results stay robust after we exclude these four recalls from our sample (see Columns 3.1 and 3.2 of Tables C1 and C2).

Recall ID	Manufacturer	Year	Recall reason	Recall size	Comment
1	Toyota	2010	Faulty accelerator pedals	2,300,000	
2	GM	2010	Steering problems	1,300,000	
3	GM	2010	Fire risk	1,500,000	
4	Toyota	2010	Engine problem	1,100,000	
5	Nissan	2010	Faulty ignition	2,140,000	
6	Honda	2010	Defective headlight wiring	1,350,000	
7	Toyota	2011	Fuel leaks	1,700,000	
8	BMW	2012	Battery cable issue	1,300,000	
9	Toyota	2012	Power window problem	7,430,000	
10	Toyota	2012	Pump, steering issues	2,700,000	
11	Hyundai/Kia	2013	Faulty break switch	1,620,000	
12	VW	2013	Electronic and drive-system flaws	2,600,000	
13	GM	2014	Ignition switch	1,500,000	
14	GM	2014	Ignition switch	1,500,000	
15a	GM	2014	Ignition switch	2,200,000	
15b	Toyota	2014	Spiral cable and seat rails issues	7,000,000	Merged with recall ID 15a
16	GM	2014	Ignition switch	2,700,000	
17	Ford	2014	Loss of power steering	1,100,000	
18	GM	2014	Ignition switch	3,400,000	
19	GM	2014	Ignition switch	8,450,000	
20	Suzuki	2015	Smoking ignition switch	2,000,000	
21	Chrysler	2015	Software issue	1,400,000	
22	VW	2015	Emission manipulation	11,000,000	
23	VW	2015	Emission manipulation	8,500,000	
24	Chrysler	2016	Rollaway issue	1,100,000	
25	Mazda	2016	Defect in tailgates	2,300,000	
26a	GM	2016	Airbag software problems	4,300,000	
26b	Ford	2016	Door latch issues	1,500,000	Merged with recall ID 26a
27	Chrysler	2016	Airbag defect	1,900,000	

Table C2: Variables

Note: Letter *r* indexes the focal recall. *t* is the year of the announcement of the focal recall, and thus, $t-1$ is the year before the year of the recall. The letter *s* denotes the focal supplier, and the letter *m* denotes the recalling manufacturer. We multiply the value of the dependent variable by 100 for ease of interpretation. That is, the regression coefficients should be interpreted as the percentage change of a supplier firm's shareholder value.

Variable	Measure and Reference research	Data source
Supplier-specific outcome variable		
Supplier's shareholders' reactions$_{s,[-1,1]}$	The supplier *s*' cumulative abnormal return (CAR) to the focal recall by a manufacturer-customer, measured in the event window [−1,1] where 0 is the recall announcement day (Jacobs and Singhal 2020)	CRSP
Supplier-specific explanatory variables		
Supplier's voluntary disclosure (or customer information)$_{s,y-1}$	= 1 if the supplier *s* disclosed (1) its "major" customers' names and (2) the sales revenue received from and names of nonmajor customers in the year $y-1$; 0, otherwise	Supplier *s*' annual report available on EDGAR (https://www.sec.gov/edgar.shtml) or its website
Supplier's revenue dependence (on the recalling manufacturer)$_{s,y-1}$	The supplier *s*' sales revenue from the recalling manufacturer in year $t-1$ divided by *s*' total sales revenue (Compustat variable name: SALE) in year $t-1$ (Jacobs and Singhal 2020; Jacobs, Singhal, and Zhan 2022; Qiu, Xu, Yeung, and Zeng 2024)	Supplier *s*' annual report available on EDGAR (https://www.sec.gov/edgar.shtml) or its website
Five recall-specific explanatory variables (recall severity proxies)		
Recall size$_r$	Natural logarithm of the number of vehicles affected by the focal recall.	News reports
Recall news volume$_r$	The number of articles covering the recall in six news outlets: *The Wall Street Journal*, *USA Today*, *The New York Times*, *Washington Post*, *New York Post*, and *Financial Times*	Factiva
Recall news sentiment$_r$	News sentiment computed by the *Syuzhet* R-package, which relies on four lexicons to assess the emotionality of words. Values closer to −1 (+1) indicate more negative (positive) sentiment of the news articles announcing the recall, 0 indicates neutral sentiment.	Factiva
Customer harm$_r$	= 1 if the news reports injuries and/or deaths related to the recall, and 0 if no injuries or deaths have been reported by the news media	News reports
Software recall$_r$	= 1 if the recall is related to a software issue and 0 if the recall is related to a hardware issue (e.g., mechanical or electronic parts) or a combination of software and hardware issues.	News reports
Nine supplier-specific covariates		
Supplier's customer breadth$_{s,y-1}$	Supplier *s*' number of major customers in $y-1$.	Supplier *s*' annual report available on EDGAR (https://www.sec.gov/edgar.shtml) or its website
Supplier's customer depth$_{s,y-1}$	The sum of supplier *s*' sales revenue from each of its major customers divided by its	

	sales revenue from all customers (Compustat data item: SALE). All values in $y-1$.	
Supplier's relationship equity$_{s,y}$	Supplier *s*' trade receivables (RECT) divided by its total assets (AT). Both values in *y*.	Compustat
Supplier's R&D$_{s,y}$	Supplier *s*' research and development expense (XRD) divided by its total assets (AT). Both values in *y*.	Compustat
Supplier's liquidity$_{s,y}$	Supplier *s*' current assets (ACT) divided by its current liabilities (LCT). Both values are in *y*.	Compustat
Supplier's age$_{s,y}$	Difference between *y* and supplier *s*' year of initial public offering (year component of IPODATE).	CRSP
Supplier's profitability$_{s,y}$	Supplier *s*' net income (NI) divided by its total assets (AT). Both values in *y*.	Compustat
Supplier's size$_{s,y}$	Natural logarithm of supplier *s*' number of employees in *y*.	Compustat
Supplier's gross margin$_{s,y}$	Supplier *s*' sales revenue (SALE) minus costs of goods sold (COGS) divided by sales revenue (SALE). Both values in *y*.	Compustat
Three recall-specific control variables		
Recall scope$_r$	1 = global, 0 = US	NHTSA and news reports
Recall initiator$_r$	Whether an investigation initiated by a government agency prompted the manufacturer to issue the recall, or the manufacturer proactively issued the recall (reference category). Missing information is reflected in the "not available" category.	NHTSA and news reports
Clustered recall$_r$	1 = if the manufacturer-customer announced two or more recalls within the three-day window of the focal event, 0 = otherwise	Factiva
Additional recall$_r$	1 = if recalls other than the focal one was mentioned in the announcement, 0 = otherwise	Factiva
Four manufacturer-specific control variables		
Manufacturer's margin$_{m,y}$	Manufacturer *m*'s sales revenue minus its costs of goods sold divided by its sales revenue. Both values in *y*.	Manufacturer's annual report
Manufacturer's region of headquarters$_m$	Asia, Europe, or the U.S. (reference category)	Manufacturer's website
Manufacturer's reputation$_{m,y}$ ***(robustness checks 2.1 and 2.2)***	Reputation scores from Forbes's list of most admired companies	Fortune
Manufacturer's market share$_{m,y}$ ***(robustness checks 2.1 and 2.2)***	Manufacturer sales in year *y* divided by the sales of the top 10 automotive sellers in the year *y*	OICA reports 2010-2016

Table C3: Justification for Covariates' Inclusion

Variable	Reason for inclusion	Reference research to justify inclusion
	Supplier-specific covariates	
Supplier's customer breadth	Suppliers with broader customer portfolios could have stronger relationships with their customers, which could influence the reactions of shareholders to the recall.	Current study
Supplier's customer depth	Suppliers with deeper customer portfolios could have stronger relationships with their customers, which could influence the reactions of shareholders to the recall.	Current study
Supplier's customer equity	Higher customer equity implies stronger relationships with customers, which could influence the reactions of shareholders to the recall.	Current study
Supplier's R&D	Greater R&D leads to suppliers' products being more innovative and more competitive	Astvansh, Wang, and Shi (2022)
Supplier's liquidity	The amount of liquid assets can inform shareholders if suppliers have enough resources to weather a crisis.	Kini, Shenoy, and Subramaniam (2017)
Supplier's age	Older suppliers had more time to develop strong relationships with customers, which can protect them during crisis periods.	Mukherjee et al. (2022)
Supplier's profitability	More profitable suppliers have greater resources to face a crisis period	Eilert et al. (2017)
Supplier's size	Larger suppliers have more market power that can be used to weather a crisis.	Gao et al. (2015)
Supplier's gross margin	Supplier's gross margin reflects the supplier's share of the value jointly created with customers. It proxies the supplier's power over customers, which may be leveraged in case of crisis.	Current study
	Recall-specific covariates	
Recall scope: global vs. US	Shareholders may be more informed about U.S. recalls than non-U.S. recalls.	Current study
Recall initiator: government vs. manufacturer	Different types of recalls (for example, initiated by the government vs. the manufacturer) have different impacts on shareholders	Chen, Ganesan, and Liu (2009)
Recall initiator: not available vs. manufacturer	Different types of recalls (for example, initiated by the government vs. the manufacturer) have different impacts on shareholders	Chen, Ganesan, and Liu (2009)
Clustered recall	Different types of recalls (clustered vs. non-clustered) have different impacts on shareholders	Mukherjee et al. (2022)
Additional recall	Additional recall may indicate more severe recall damage and ineffective recall management	Current study
	Manufacturer-specific covariates	
Manufacturer's gross margin	Manufacturer's gross margin reflects the manufacturer's share of the value jointly created with suppliers. It proxies the manufacturer's power over suppliers, which may be leveraged in case of crisis.	Current study
Region of manufacturer's headquarters: Asia vs. the United States	Manufacturers from different regions vary in the strength of their relationships with suppliers, which could be an important signal for shareholders during a product recall.	Current study
Region of manufacturer's headquarters: Europe vs. the	Manufacturers from different regions vary in the strength of their relationships with suppliers, which could be an important signal for shareholders during a product recall.	Current study

United States		
Manufacturer's reputation	Strong reputation of manufacturers can mitigate the negative impact of product recalls.	Eilert et al. (2017)
Manufacturer's market share	Market share can be a sign of customer loyalty, which can assuage the detrimental effect of product recalls.	Cleeren, van Heerde and Dekimpe (2013)

Table C4: Descriptive Statistics and Correlation Coefficients

Note: All correlations larger than the absolute value of .068 are significant at the 5% level. Although we mean-center all continuous variables in our regressions, the reported mean and SD are for raw/non-centered variables. *Italics* indicate categorical variables.

	n	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1 Supplier's shareholders' reactions [−1,1]	896	-0.32	3.44	1.00																										
2 *Supplier's voluntary disclosure*	896	0.24	0.43	0.06	1.00																									
3 Supplier's revenue dependence	223	17.02	13.74	-0.13	-0.26	1.00																								
4 Recall size	896	14.75	0.74	-0.07	0.00	-0.02	1.00																							
5 Recall news volume	896	3.02	1.81	-0.01	-0.02	-0.05	0.19	1.00																						
6 Recall news sentiment	896	-2.40	5.48	-0.15	0.02	0.04	0.05	-0.06	1.00																					
7 *Customer harm*	896	0.16	0.37	-0.02	0.00	0.16	0.09	0.07	-0.10	1.00																				
8 *Software recall*	896	0.13	0.33	-0.10	0.03	-0.12	0.40	0.05	0.39	-0.15	1.00																			
9 Supplier's customer breadth	896	0.40	0.76	0.03	0.10	0.04	-0.01	-0.04	0.00	-0.01	0.00	1.00																		
10 Supplier's customer depth	896	1.46	1.58	0.04	0.34	-0.11	0.02	-0.01	0.02	-0.02	0.02	0.21	1.00																	
11 Supplier's relationship equity	896	0.19	0.08	0.04	0.39	-0.23	-0.02	-0.01	0.01	-0.02	0.01	-0.06	0.46	1.00																
12 Supplier's R&D	896	0.04	0.04	-0.04	0.12	-0.22	0.00	0.00	0.00	-0.01	0.03	0.00	0.01	0.04	1.00															
13 Supplier's liquidity	896	2.15	1.44	0.01	-0.11	0.02	-0.03	-0.02	-0.01	0.01	-0.03	0.64	-0.04	-0.30	0.20	1.00														
14 Supplier's age	896	31.06	23.00	0.04	-0.40	0.06	0.03	0.05	0.00	0.02	0.00	-0.19	-0.41	-0.23	-0.17	-0.07	1.00													
15 Supplier's profitability	896	0.04	0.10	0.07	0.11	0.02	0.01	-0.04	0.01	0.00	0.05	0.21	0.15	0.10	-0.44	0.12	0.17	1.00												
16 Supplier's size	896	8.46	2.10	0.07	-0.33	-0.03	0.02	0.03	-0.01	0.00	-0.01	-0.25	-0.39	-0.37	-0.43	-0.32	0.46	0.28	1.00											
17 Supplier's gross margin	896	0.26	0.14	-0.02	-0.16	-0.13	0.01	-0.01	0.01	0.02	0.02	0.05	-0.26	-0.27	0.35	0.50	0.29	0.20	0.04	1.00										
18 *Recall scope*	896	0.55	0.50	-0.05	0.00	-0.10	0.06	-0.25	-0.13	-0.27	0.11	0.00	0.02	0.00	0.02	0.02	-0.01	0.01	-0.01	0.02	1.00									
19 *Recall initiator: government*	896	0.20	0.40	-0.04	-0.02	-0.05	0.13	0.09	0.23	-0.01	0.14	-0.01	-0.01	-0.02	0.00	-0.01	0.03	-0.02	0.02	0.00	-0.34	1.00								
20 *Recall initiator: not available*	896	0.40	0.49	0.06	0.02	-0.02	-0.10	-0.39	-0.47	-0.13	-0.31	0.03	0.01	0.01	-0.01	0.02	-0.02	0.02	-0.02	-0.01	0.68	-0.41	1.00							
21 *Recall initiator: manufacturer*	896	0.40	0.49	-0.03	0.00	0.06	0.00	0.32	0.28	0.13	0.20	-0.01	0.00	0.00	0.02	-0.01	0.00	0.00	0.00	0.01	-0.40	-0.41	-0.66	1.00						
22 *Clustered recall*	896	0.08	0.27	0.02	0.02	0.11	0.40	0.23	-0.09	0.65	-0.11	-0.01	0.02	-0.02	0.00	-0.01	0.02	0.01	0.01	0.01	-0.32	-0.15	-0.23	0.35	1.00					
23 *Additional recall*	896	0.64	0.48	0.09	-0.05	0.04	0.08	0.47	-0.27	0.10	-0.50	-0.03	-0.04	-0.02	-0.03	-0.01	0.05	-0.04	0.05	-0.02	-0.23	0.15	-0.10	-0.03	0.22	1.00				
24 Manufacturer's gross margin	896	0.21	0.06	-0.07	-0.04	-0.16	0.00	-0.32	0.19	-0.12	0.09	0.03	0.01	-0.03	0.03	0.04	-0.04	0.04	0.01	0.01	0.31	-0.14	0.02	0.10	-0.03	-0.14	1.00			
25 *Region of manufacturer's headquarters: Asia*	896	0.32	0.47	0.13	-0.04	-0.21	0.01	0.04	-0.36	0.10	-0.26	0.05	-0.03	-0.04	-0.02	0.05	-0.03	0.01	0.02	-0.03	-0.15	0.02	0.12	-0.13	0.09	0.14	0.20	1.00		
26 *Region of manufacturer's headquarters: Europe*	896	0.17	0.37	-0.13	-0.03	-0.13	0.35	-0.19	0.32	-0.20	0.55	-0.01	0.01	-0.02	0.04	0.00	0.00	0.02	0.01	0.02	0.40	0.07	-0.13	0.07	-0.13	-0.16	0.59	-0.30	1.00	
27 *Region of manufacturer's headquarters: US*	896	0.52	0.50	-0.02	0.06	0.27	-0.26	0.10	0.10	0.06	-0.17	-0.04	0.01	0.05	-0.01	-0.05	0.02	-0.03	-0.03	0.01	-0.16	-0.07	-0.01	0.07	0.01	-0.01	-0.63	-0.70	-0.46	1.00

WEB APPENDIX D: ROBUSTNESS TESTS

Table D1: Robustness Tests of Voluntary Disclosure and Revenue Dependence

Note: For each robustness test (e.g., Fama-French[1,1]), the first column is based on all observations (e.g., 1.1), while the second column is based on the subsample of observations for which revenue dependence is observed (e.g., 1.2).

Adjustment =	No Year-FE		Additional Controls		DV: Fama-French[1,1]		DV Winsorized		Clustered Recalls Removed		Only suppliers headquartered in North America	
	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2	6.1	6.2
Supplier's voluntary disclosure: Yes vs. no	0.831** (0.314)		0.777** (0.350)		0.855** (0.334)		0.655** (0.264)		0.925** (0.364)		0.857** (0.368)	
Revenue dependence		-0.0385* (0.0205)		-0.0449* (0.0226)		-0.0341* (0.0194)		-0.0293** (0.0137)		-0.0454* (0.0230)		-0.0414* (0.0234)
Recall size	-0.598** (0.225)	-0.751 (0.603)	-0.886** (0.331)	-0.878 (0.780)	-0.792*** (0.239)	-0.966* (0.474)	-0.855*** (0.238)	-1.335*** (0.371)	-0.761*** (0.281)	-1.330*** (0.389)	-0.745** (0.282)	-1.045* (0.564)
Recall news volume	-0.302*** (0.0736)	-0.655*** (0.189)	-0.217** (0.0937)	-0.527** (0.207)	-0.417*** (0.0712)	-0.748*** (0.191)	-0.412*** (0.0775)	-0.736*** (0.182)	-0.427*** (0.0767)	-0.766*** (0.190)	-0.456*** (0.0743)	-0.778*** (0.223)
Recall news sentiment	-0.0580*** (0.0206)	0.0481 (0.0493)	-0.0424* (0.0240)	0.0365 (0.0608)	-0.116*** (0.0332)	-0.173** (0.0813)	-0.117*** (0.0307)	-0.146* (0.0768)	-0.134*** (0.0383)	-0.162* (0.0871)	-0.166*** (0.0377)	-0.193* (0.0982)
Customer harm	-1.135** (0.520)	-1.321 (1.393)	-1.063* (0.555)	-1.233 (1.380)	-0.455 (0.472)	-1.024 (1.552)	-0.697 (0.468)	-1.296 (1.356)	-0.689 (0.537)	-1.114 (1.521)	-0.810 (0.626)	-1.578 (1.628)
Software defect	1.527** (0.609)	2.035 (2.014)	1.251* (0.631)	1.398 (2.007)	2.318** (1.046)	3.489* (1.709)	2.379** (0.986)	3.209* (1.709)	2.244** (1.035)	3.453* (1.791)	2.412* (1.349)	4.063** (1.934)
Supplier's customer breadth	-0.148 (0.128)	-0.233 (0.346)	-0.105 (0.144)	-0.271 (0.381)	-0.103 (0.130)	-0.167 (0.395)	-0.0781 (0.115)	-0.319 (0.238)	-0.163 (0.143)	0.0923 (0.829)	-0.283* (0.165)	0.0209 (0.831)
Supplier's customer depth	0.167** (0.0823)	0.137 (0.107)	0.233** (0.100)	0.194* (0.112)	0.152* (0.0789)	0.0913 (0.108)	0.151*** (0.0557)	0.0545 (0.0791)	0.206** (0.0908)	0.151 (0.145)	0.208** (0.0939)	0.0963 (0.138)
Supplier's customer equity	3.297* (1.723)	-9.378 (5.711)	2.222 (2.362)	-9.888* (5.773)	2.777 (1.783)	-9.062 (5.507)	1.562 (1.305)	-8.625** (3.728)	2.71 (1.746)	-11.34* (6.313)	1.795 (2.080)	-11.26 (9.250)
Supplier's R&D	1.907 (3.276)	2.931 (8.408)	3.338 (3.346)	4.747 (8.468)	1.885 (3.503)	3.705 (7.939)	1.704 (2.443)	2.907 (4.857)	1.209 (3.623)	4.907 (12.62)	3.545 (3.711)	1.710 (13.53)
Supplier's liquidity	0.400** (0.165)	0.239 (0.209)	0.383** (0.185)	0.298 (0.226)	0.371** (0.163)	0.278 (0.232)	0.275** (0.119)	0.260* (0.150)	0.429** (0.182)	0.120 (0.477)	0.511** (0.200)	0.0568 (0.518)
Supplier's age	0.0109* (0.00592)	0.00246 (0.00938)	0.0140** (0.00580)	0.00665 (0.00885)	0.00996 (0.00597)	-0.000335 (0.00957)	0.00925 (0.00552)	-0.000147 (0.00677)	0.0117* (0.00618)	0.00437 (0.0157)	0.00912 (0.00716)	0.00956 (0.0177)
Supplier's profitability	-0.593 (1.275)	7.845** (3.253)	-1.446 (1.403)	9.997*** (3.322)	-0.439 (1.331)	7.565** (2.925)	0.0489 (1.030)	8.929*** (2.536)	-0.495 (1.456)	6.757* (3.927)	-0.0476 (1.404)	7.892** (3.649)
Supplier's size	0.312*** (0.109)	-0.0714 (0.171)	0.296** (0.132)	-0.120 (0.174)	0.318*** (0.113)	-0.0654 (0.175)	0.220*** (0.0760)	-0.0441 (0.114)	0.326*** (0.121)	-0.200 (0.240)	0.366** (0.138)	-0.149 (0.261)
Supplier's gross margin	-1.680 (1.119)	-8.726 (5.599)	-1.771 (1.212)	-10.38* (5.827)	-1.752 (1.184)	-8.736 (5.677)	-1.209 (0.818)	-6.196* (3.615)	-1.455 (1.194)	-11.97 (9.751)	-2.562* (1.309)	-9.031 (9.455)
Recall scope: global vs.	0.320	0.138	-0.0245	0.0468	-1.044	-1.444*	-1.065**	-1.401**	-0.724	-1.550**	-0.726	-1.461

US	(0.529)	(0.683)	(0.402)	(0.937)	(0.699)	(0.763)	(0.441)	(0.658)	(0.849)	(0.747)	(0.838)	(0.891)
Recall initiator:	-0.230	0.487	-0.881	-0.315	-0.413	0.464	-0.419	0.510	-0.529	0.299	-0.751	0.930
government vs. manufacturer	(0.491)	(0.819)	(0.546)	(0.878)	(0.534)	(0.878)	(0.310)	(0.880)	(0.601)	(0.932)	(0.626)	(1.026)
Recall initiator: not	-0.371	0.0305	0.0635	0.0383	0.346	0.415	0.296	1.022	-0.140	0.768	-0.510	0.904
available vs. manufacturer	(0.468)	(1.354)	(0.451)	(1.298)	(0.631)	(1.387)	(0.446)	(1.138)	(0.749)	(1.291)	(0.681)	(1.526)
Clustered recall	1.750**	0.988	1.697*	0.780	0.811	-0.0714	1.256*	1.108			0.535	0.392
	(0.817)	(1.966)	(0.996)	(1.634)	(0.721)	(1.904)	(0.638)	(1.620)			(0.897)	(2.060)
Additional recall	1.222***	2.007	0.686*	1.321	0.0506	0.601	0.0652	1.269	0.225	-0.00181	-0.220	1.007
	(0.356)	(1.222)	(0.401)	(1.608)	(0.459)	(1.589)	(0.428)	(1.440)	(0.624)	(2.233)	(0.585)	(1.989)
Manufacturer's gross	-5.584*	0.724	-8.267**	-1.673	-4.927*	20.53	-5.023*	12.88	-3.335	15.77	-2.756	36.57**
margin	(3.052)	(10.22)	(3.408)	(11.07)	(2.914)	(15.56)	(2.710)	(13.28)	(4.579)	(14.66)	(3.520)	(14.63)
Region of manufacturer's	0.851**	2.975**	1.134**	3.125*	1.652***	3.216***	1.588***	3.211***	1.411*	4.251**	1.686***	3.280**
headquarters: Asia vs. the United States	(0.412)	(1.297)	(0.440)	(1.527)	(0.409)	(0.863)	(0.417)	(0.905)	(0.801)	(1.576)	(0.473)	(1.217)
Region of manufacturer's	-0.654	-2.475	-0.496	-2.012	1.502	-0.863	1.834**	0.427	1.116	0.701	1.304	-2.681
headquarters: Europe vs. the United States	(0.814)	(2.556)	(0.954)	(2.946)	(0.950)	(2.554)	(0.778)	(1.827)	(1.564)	(1.874)	(1.030)	(2.875)
Manufacturer's reputation			0.390	0.181								
			(0.368)	(0.770)								
Manufacturer's market			4.465	5.189								
share			(3.306)	(7.089)								
Year	-0.0422	0.215	-0.0231	0.240								
	(0.0742)	(0.202)	(0.0780)	(0.210)								
Constant	83.39	-434.3	44.92	-484.7	-1.809***	-2.033	-1.673***	-2.314*	-1.592***	-2.806*	-1.388**	-2.063
	(149.4)	(407.2)	(157.1)	(423.1)	(0.499)	(1.277)	(0.478)	(1.140)	(0.539)	(1.456)	(0.548)	(1.314)
Year FE	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES
Clustered SE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	896	223	815	199	896	223	896	223	827	194	737	189
R-squared	0.086	0.2393	0.092	0.236	0.107	0.275	0.114	0.300	0.069	0.274	0.111	0.295

*** p<0.01, ** p<0.05, * p<0.1

Table D2: Robustness Tests of Voluntary Disclosure with Endogeneity Correction

Note: For each robustness test (e.g., Fama-French[1,1]), the first column is based on the first-stage regression of the control function (e.g., 1.1) while the second column is based on the second-stage regression of the control function (e.g., 1.2).

Adjustment=	No YFE		Additional Controls		DV: FF11		DV Winsorized		Clustered Recalls Removed		Only suppliers HQ in North America	
	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2	6.1	6.2
Supplier's voluntary disclosure:		1.652***		1.746***		1.720***		1.321***		1.726***		1.639**
Yes vs. no		(0.534)		(0.572)		(0.577)		(0.447)		(0.582)		(0.646)
Recall size	0.0361	-0.599***	-0.0853	-0.860***	0.0225	-0.784***	0.0225	-0.849***	-0.00548	-0.752***	0.0757	-0.742***
	(0.231)	(0.212)	(0.345)	(0.319)	(0.271)	(0.255)	(0.271)	(0.231)	(0.307)	(0.278)	(0.293)	(0.281)
Recall news volume	-0.0450	-0.302***	-0.0574	-0.212*	-0.0442	-0.416***	-0.0442	-0.411***	-0.0482	-0.427***	-0.0616	-0.454***
	(0.0973)	(0.104)	(0.112)	(0.120)	(0.108)	(0.116)	(0.108)	(0.0935)	(0.110)	(0.118)	(0.119)	(0.131)
Recall news sentiment	0.0316	-0.0592**	0.0345	-0.0439*	0.0180	-0.117***	0.0180	-0.118***	0.0195	-0.136***	0.0104	-0.167***
	(0.0277)	(0.0239)	(0.0317)	(0.0244)	(0.0411)	(0.0390)	(0.0411)	(0.0328)	(0.0424)	(0.0403)	(0.0448)	(0.0450)
Customer harm	0.330	-1.144***	0.102	-1.039**	0.133	-0.450	0.133	-0.693	0.157	-0.685	0.380	-0.822
	(0.486)	(0.429)	(0.549)	(0.487)	(0.518)	(0.467)	(0.518)	(0.437)	(0.526)	(0.474)	(0.579)	(0.586)
Software recall	0.122	1.550**	0.172	1.268**	-1.287	2.415**	-1.287	2.453***	-1.317	2.336**	-1.375	2.523**
	(0.696)	(0.635)	(0.721)	(0.616)	(1.558)	(0.970)	(1.558)	(0.864)	(1.597)	(0.918)	(1.761)	(1.198)
Supplier's customer breadth	1.563***	-0.218	1.505***	-0.183	1.575***	-0.176	1.575***	-0.134	1.669***	-0.232	1.495***	-0.352
	(0.294)	(0.188)	(0.295)	(0.185)	(0.291)	(0.187)	(0.291)	(0.167)	(0.306)	(0.195)	(0.317)	(0.232)
Supplier's customer depth	-0.0520	0.178*	-0.0274	0.245**	-0.0491	0.163*	-0.0491	0.159**	-0.0735	0.216**	-0.121	0.222*
	(0.0980)	(0.0980)	(0.102)	(0.0961)	(0.0988)	(0.0985)	(0.0988)	(0.0776)	(0.106)	(0.0998)	(0.113)	(0.118)
Supplier's customer equity	6.225***	2.957	5.737***	1.928	6.346***	2.425	6.346***	1.290	6.410***	2.380	2.698	2.041
	(2.098)	(2.569)	(2.195)	(2.527)	(2.104)	(2.675)	(2.104)	(1.917)	(2.243)	(2.659)	(2.441)	(3.082)
Supplier's R&D	22.73***	0.548	23.41***	1.718	23.11***	0.453	23.11***	0.600	24.49***	-0.0879	17.76***	2.909
	(4.220)	(4.023)	(4.496)	(4.096)	(4.285)	(3.896)	(4.285)	(3.412)	(4.570)	(4.180)	(4.623)	(4.463)
Supplier's liquidity	-1.310***	0.487***	-1.273***	0.488***	-1.321***	0.464***	-1.321***	0.346**	-1.435***	0.516***	-1.340***	0.607***
	(0.244)	(0.178)	(0.248)	(0.175)	(0.244)	(0.179)	(0.244)	(0.147)	(0.258)	(0.184)	(0.268)	(0.213)
Supplier's age	-0.102***	0.0158**	-0.102***	0.0197***	-0.104***	0.0151**	-0.104***	0.0132**	-0.104***	0.0164**	-0.112***	0.0138*
	(0.0128)	(0.00623)	(0.0135)	(0.00653)	(0.0129)	(0.00635)	(0.0129)	(0.00544)	(0.0137)	(0.00649)	(0.0151)	(0.00785)
Supplier's profitability	12.22***	-1.735	12.96***	-2.919	12.39***	-1.650	12.39***	-0.884	12.87***	-1.593	12.99***	-1.097
	(1.889)	(2.073)	(2.007)	(1.947)	(1.915)	(2.094)	(1.915)	(1.631)	(2.036)	(2.123)	(2.141)	(2.119)
Supplier's size	-0.609***	0.353***	-0.643***	0.350***	-0.616***	0.361***	-0.616***	0.254***	-0.635***	0.368***	-0.865***	0.421***
	(0.122)	(0.119)	(0.130)	(0.126)	(0.123)	(0.117)	(0.123)	(0.0832)	(0.131)	(0.124)	(0.145)	(0.141)
Supplier's gross margin	-1.854	-1.666	-2.750	-1.705	-1.950	-1.735	-1.950	-1.197	-2.053	-1.445	-1.195	-2.671*
	(2.289)	(1.322)	(2.392)	(1.239)	(2.296)	(1.294)	(2.296)	(1.113)	(2.387)	(1.322)	(2.478)	(1.395)
Recall scope: global vs. US	-0.162	0.326	-0.0276	-0.0432	0.0146	-1.048	0.0146	-1.068**	-0.0404	-0.726	-0.185	-0.711
	(0.475)	(0.526)	(0.525)	(0.528)	(0.609)	(0.678)	(0.609)	(0.474)	(0.643)	(0.673)	(0.657)	(0.749)
Recall initiator: government vs. manufacturer	-0.0852	-0.232	-0.0319	-0.900**	-0.110	-0.411	-0.110	-0.417	-0.147	-0.526	-0.223	-0.740
	(0.352)	(0.432)	(0.417)	(0.443)	(0.389)	(0.431)	(0.389)	(0.321)	(0.413)	(0.493)	(0.427)	(0.505)
Recall initiator: not available vs. manufacturer	0.318	-0.384	0.130	0.0684	0.0497	0.332	0.0497	0.285	0.0989	-0.154	0.0134	-0.523

	(0.529)	(0.565)	(0.592)	(0.602)	(0.582)	(0.668)	(0.582)	(0.479)	(0.627)	(0.690)	(0.627)	(0.715)
Clustered recall	-0.350	1.750**	-0.198	1.649*	-0.285	0.781	-0.285	1.233			-0.837	0.554
	(0.877)	(0.832)	(1.018)	(0.877)	(1.005)	(0.901)	(1.005)	(0.754)			(1.119)	(1.105)
Additional recall	0.135	1.230***	0.197	0.697*	0.190	0.0541	0.190	0.0679	0.108	0.232	0.129	-0.209
	(0.393)	(0.377)	(0.433)	(0.381)	(0.510)	(0.462)	(0.510)	(0.403)	(0.637)	(0.586)	(0.563)	(0.507)
Manufacturer's gross margin	-0.331	-5.489*	-1.430	-7.980**	-2.280	-4.533	-2.280	-4.720	-2.858	-2.955	-1.239	-2.473
	(3.408)	(3.161)	(3.973)	(3.423)	(4.741)	(4.499)	(4.741)	(3.530)	(5.513)	(5.093)	(5.242)	(4.979)
Region of manufacturer's	0.0341	0.860**	0.327	1.107***	0.178	1.645***	0.178	1.583***	0.325	1.399*	0.119	1.674***
headquarters:	(0.401)	(0.370)	(0.450)	(0.363)	(0.508)	(0.439)	(0.508)	(0.392)	(0.777)	(0.784)	(0.549)	(0.476)
Asia vs. the United States												
Region of manufacturer's	-0.774	-0.614	-0.266	-0.487	-0.354	1.500	-0.354	1.832**	-0.139	1.106	-0.221	1.291
headquarters:	(0.706)	(0.838)	(0.833)	(0.871)	(1.068)	(1.014)	(1.068)	(0.880)	(1.403)	(1.354)	(1.159)	(1.110)
Europe vs. the United States												
Year	0.169*	-0.0517	0.205**	-0.0403								
	(0.0865)	(0.0834)	(0.0903)	(0.0801)								
Manufacturer's reputation			-0.267	0.409								
			(0.340)	(0.327)								
Manufacturer's market share			5.776	3.670								
			(3.954)	(3.707)								
News coverage of the supplier	-0.739**		-0.665**		-0.747**		-0.747**		-0.756**		-0.405	
	(0.302)		(0.326)		(0.302)		(0.302)		(0.322)		(0.340)	
Control function		-0.430**		-0.504***		-0.453**		-0.349**		-0.424**		-0.397*
		(0.189)		(0.186)		(0.191)		(0.149)		(0.197)		(0.204)
Constant	-343.7**	102.2	-417.1**	79.34	-3.206***	-2.003***	-3.206***	-1.822***	-3.334***	-1.770***	-3.743***	-1.552**
	(174.3)	(167.9)	(182.0)	(161.3)	(0.671)	(0.538)	(0.671)	(0.501)	(0.763)	(0.646)	(0.752)	(0.622)
Year FE	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES
Observations	896	896	815	815	896	896	896	896	827	827	737	737
Adjusted (Pseudo) R-squared	0.481	0.062	0.488	0.065	0.484	0.079	0.484	0.086	0.487	0.071	0.45	0.076

Note: *** p<0.01, ** p<0.05, * p<0.1.
The control function method (for endogeneity correction) bootstrapped the standard errors 500 times.