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When Supply-Chain Disruptions Matter

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Working Paper

13-006

January 3, 2012

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November 13, 2012

Abstract

Supply-chain disruptions can have a material effect on company value, but this impact varies considerably and countermeasures can be costly. Thus, it is important for managers and investors to recognize the types of disruptions and the organizational factors that lead to the worst outcomes. Prior research remains unsettled as to whether improvements to firm operational efficiency aggravate or alleviate the impact of disruptions. Improved operational efficiency may leave firms more exposed when a disruption occurs, or it may improve firms' agility and allow them to respond more effectively to a disruption. We hypothesize that the impact of improved operational efficiency depends on whether the disruption is due to factors that are internal versus external to the firm and its supply chain. Examining more than 500 disruptions, we find that a higher rate of improvement in operating performance aggravates the impact of internal disruptions but not external disruptions. Finally, we take advantage of the enforcement date of Section 409 of the Sarbanes Oxley Act to show that managers exhibit systematic bias in the disruptions they choose to announce. We control for this effect in our model specifications.

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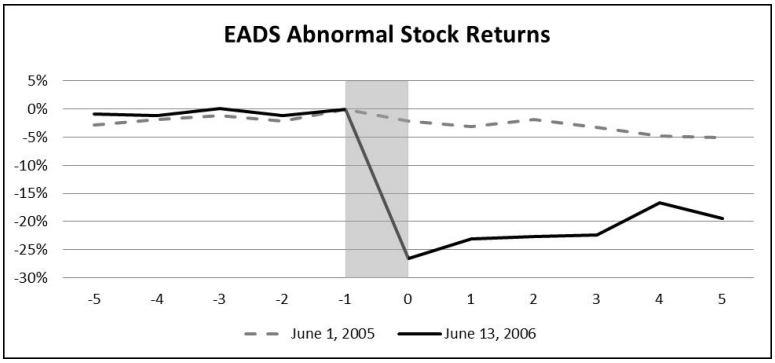
1 Introduction

Disruptions to a firm's operations and supply chain can be costly to the firm and its investors (Hendricks and Singhal 2003, 2005a). Many companies have been subjected to such disruptions, and the impact on company value varies widely. It is not clear, however, if disruption and firm characteristics systematically influence this impact. Raman et al. (2009) provides an example that motivates this question. The authors examine the stock price impact of two similarly situated but separate disruption announcements made by the Airbus division of the European Aeronautic Defence and Space Company N.V. (EADS), a manufacturer of large commercial and military aircraft. In the first announcement, on June 1, 2005, Airbus revealed that it was experiencing problems with the supply and installation of electrical harnesses for its new A380 super-jumbo jet, and that the delivery of the aircraft would be delayed by approximately six months as a result. EADS stock was not significantly impacted by the announced disruption, falling by 2 percent relative to a market benchmark, which is within the normal daily volatility range of the stock.

Approximately one year later, after the close of trading on June 13, 2006, Airbus again announced that issues with the supply and installation of electrical harnesses would lead to further six-month delay in the delivery of the A380. Airbus also specified the impact of the disruption on earnings before interest and tax to be €500 million per year for four years. When market trading opened the next day, the value of EADS stock plummeted by over 26 percent, equivalent to a loss in market capitalization of approximately €5.4 billion and far exceeding Airbus' earnings estimates. Figure 1 captures the movement of the EADS stock five trading days before and after the two disruptions.

Though the two announcements have many factors in common – the same company, the same product, the same attributed cause, roughly the same projected delay, the same season – other factors differ, notably the additional earnings information released with the second announcement, that the second announcement has a precedent announcement, and differences in operational performance leading up to the announcements. In this paper we investigate what may explain some of the difference in the impact of disruptions on firm value. We identify factors that cause some disruptions to be more damaging to firm value using a large sample empirical analysis of quantitative archival data. Insight into this issue can help managers identify exposures and target risk-mitigation efforts.

Figure 1: Daily abnormal returns on EADS stock in the trading days surrounding the disruptions of June 1, 2005 and June 13, 2006.



We contribute to the literature in two ways. First, we examine whether managers exhibit systematic bias in choosing which disruptions to announce. This is important because it would mean that the average impact of *announced* disruptions is a biased estimate of the actual average impact of disruptions. It also has direct implications for how much time and resources management should devote to avoiding disruptions. By taking advantage of a change in U.S. securities regulations, we gain insight into this issue. Section 409 of the Sarbanes Oxley Act of 2002 (SOX), implemented during the sample period, compels firms to promptly disclose any events that may impair their operations. We capture the enforcement of Section 409 as an exogenous policy shock in our model. Our empirical findings and interviews with current and former executives provide evidence that, prior to the regulatory change, managers failed to disclose all consequential disruptions, particularly those less damaging to firm value but still material under the rubric of SOX. We control for this effect in our model specifications. We also reconcile these results with those of prior studies which identify disruptions from articles published in third-party news outlets such as the *Wall Street Journal*. Compared to our results, these studies find that disruptions have a significantly larger adverse average impact on firm value (Hendricks and Singhal 2003, 2005b). Through interviews with reporters at the *Wall Street Journal*, however, we learn that reporting on supply chain disruptions is discretionary and that such reporting is more likely if the impact of the disruption on the firm's stock price is larger.

Our second contribution is to reconcile conflicting anecdotal, theoretical and empirical evi-

dence about whether improvements to operational efficiency alleviate or aggravate the impact of disruptions. Several researchers have noted that increasing operational efficiency may undermine operational resiliency and leave firms more exposed when a disruption occurs (Sheffi 2005, Wagner and Bode 2006). Others find that operationally efficient firms which are able to quickly disseminate information within the supply chain can dampen the severity of a disruption (Craighead et al. 2007). Our analysis shows that the rate of improvement to operational efficiency can magnify the impact on firm value of some disruptions while having little impact on other disruptions. This suggests that the stock market makes distinctions based both on the nature of the disruption and the characteristics of the disrupted firm. We theorize that the market perceives disruptions attributed to factors internal to the firm or its supply chain as a sign of operational fragility and that this is exacerbated if the firm has recently improved its operating performance. External disruptions are more likely to be random events, so the market does not interpret such a disruption as a sign of operational fragility.

2 Literature Review

We build on the literature dealing with supply-chain risk management, principally those studies examining the impact of disruptions on firms and their stakeholders. Supply-chain risk management remains a nascent area of academic research, characterized by diverse viewpoints on the scope of the field and on appropriate analytical methodologies (Sodhi et al. 2012). There is abundant evidence that disruptions can have a material and negative impact on company performance (Hendricks and Singhal 2003, Sheffi 2005, Hendricks and Singhal 2005a,b). Many of these studies document important average effects, but less attention has been paid to understanding whether specific types of disruptions have different impacts on firms and their stakeholders. In an exception, Hendricks et al. (2009) report lower returns on company stock when disruptions are attributed to customers (an incremental loss of 2.74 percentage points), order changes (3.71 percentage points), or production problems (4.19 percentage points).

A range of theoretical work recognizes and defines different types of disruption risks (Christopher 2005, Kleindorfer and Saad 2005, Asbjørnslett 2008, Manuj and Mentzer 2008, Rao and Goldsby 2009). We seek to expand on this work by exploring whether different types of disruption risk have different implications for the firm. Tomlin (2006) provides some theoretical insight on this

question by developing a model of a single product firm that can source from two suppliers – one that is reliable but more expensive than the second, less reliable supplier. The author finds that characteristics of disruptions, such as the frequency and duration, affect the firm's outcomes and should therefore influence the firm's optimal sourcing strategy. Relatedly, Tang (2006) theorizes that firms may be able to influence their vulnerability to disruptions by adopting different supply-chain strategies (including postponement, and storing inventory at strategic locations).

A range of empirical research examines how firm characteristics and actions may mitigate the impact of disruptions. Braunscheidel and Suresh (2009) use survey results to investigate whether features of companies' culture and organizational integration practices are associated with the agility with which they respond to disruptions. Using qualitative findings from phone interviews and focus groups, Craighead et al. (2007) propose that supply-chain density, complexity and node criticality contribute to the severity of disruptions, and that the ability to quickly disseminate information within the supply chain dampens the severity of disruptions. Hendricks et al. (2009), one of the few empirical moderator analyses based on quantitative archival data, find that disruptions destroy less value for firms with lower ratios of sales to net property, plant and equipment, which proxies for operational slack in their model.

Our analysis differs from and builds on this literature in four important ways. First, we take advantage of a natural experiment to ascertain whether managers are likely to announce more damaging or less damaging disruptions, and then account for this possibility in the remainder of the analysis. Second, in examining whether different types of disruptions have differential effects on firm value, we consider a dichotomous categorization that has not been empirically examined: the impact of disruptions attributed to factors internal to the firm and its supply chain versus that of disruptions attributed to external factors. Third, we consider whether the impact of these different types of disruptions is moderated by the rate of change in firm operating performance, a relationship that has not previously been explored. Fourth, we utilize multiple measures of the rate of change in firm operating performance to determine whether the moderating effect is robust across a range of measures.

3 Theory and Hypotheses

3.1 Managerial Discretion in Announcing Disruptions

Anecdotal and empirical evidence indicates that disruptions have a negative impact on firm value. This result is intuitively compelling, since a disruption by its nature disturbs the firm's normal operations. Ideally, managers would announce all material disruptions to their operations. It is possible, however, that managers instead exercise significant discretion in deciding whether or not to announce material disruptions. If managers do not reveal all material disruptions, they may disproportionately under-report disruptions that are either more or less damaging to firm value, but which one is not clear ex ante. For instance, managers may have pecuniary incentives in the form of stock options, bonuses and career advancement that may induce them to avoid revealing those disruptions which are likely to have the greatest adverse impact on the firm's stock price. Such disruptions, however, are also apt to be more difficult for the firm to address discreetly, thus providing greater incentive for managers to disclose them to avoid the appearance of obfuscation. Managers may not want to risk losing investor goodwill or other reputational benefits by trying to hide a material disruption.

There is some empirical evidence in the accounting literature suggesting that managers avoid releasing bad news related to the firm's financial performance. Kothari et al. (2009) analyze the release of earnings forecasts and dividend changes and find that managers delay the release of bad news relative to good news. Skinner (1994) provides evidence in the setting of quarterly financial reporting that managers are more likely to preemptively disclose extremely bad earnings information in advance of regular earnings releases as opposed to mildly disappointing earnings information. However, earnings information and dividend changes differ from supply chain disruptions not only because they are subject to standardized reporting and third-party auditing but also because they must eventually be disclosed, the only question is when disclosure occurs. It is unclear whether management will behave in a similar fashion for supply chain disruptions when standardized reporting, third-party auditing and mandatory disclosure rules are all absent. We hypothesize:

Hypothesis 1. *Absent mandatory disclosure rules, managers disproportionately underreport disruptions that are less damaging to firm value compared to disruptions that are more damaging to*

firm value.

3.2 Attributing Disruptions to Internal or External Factors

Commonly applied models of determining the value of a firm involve forecasting the firm's future stream of cash flows and discounting those cash flows using an appropriate risk adjusted rate (Brealey et al. 2011). Such models provide an explanation for how disruptions impact firm value. Prior research has shown that on average disruptions are associated with lower future firm performance, including lower growth in sales and higher growth in costs (Hendricks and Singhal 2005a). If some types of disruptions are associated with comparatively worse future performance or increased risk, it can be expected that they will also have a more negative impact on firm value. This may occur either because a disruption is itself more costly or because the disruption portends riskier operations due to a greater likelihood of future disruptions.

We consider these effects by characterizing disruptions as either internal or external to the firm and its supply chain. One intuitive premise in cross-organizational coordination and control in organizational theory (Powell 1990, Scott and Davis 2007) and more specifically in the operations management literature (Kok and Graves 2003, Chopra and Meindl 2012) is that firms exercise more control over their operations and supply chain than over their external environment. An internal disruption may signal to the market that something is wrong with the firm's internal control mechanisms such that future disruptions, and hence lower cash flows or higher systematic risk, may be more likely. Disruptions attributed to external factors, such as environmental calamities, are often associated with random events or events over which the firm is not expected to be able to exert much control. This, in turn, may make it less likely that the market interprets such a disruption as a sign that the firm's operations are fragile.

Hypothesis 2. *External disruptions will have a milder impact on firm value than will internal disruptions.*

3.3 The Moderating Effect of the Rate of Change in Operating Performance

Several researchers have noted that removing buffers or increasing operational efficiency may undermine a firm's operational resiliency and leave it more exposed when a disruption occurs (Kleindorfer

and Wassenhove 2004, Sheffi 2005, Zsidisin et al. 2005, Wagner and Bode 2006). Although managers may unknowingly make decisions that improve the firm's short-term performance but compromise its long-term performance, the academic literature has tended to focus on situations in which managers knowingly make such tradeoffs. A rich literature documents this type of myopic behavior, which is commonly examined in economics in the context of managerial investment decisions (Stein 1988, 1989, Shleifer and Vishny 1990), and in accounting in the context of real-earnings management (Healy and Wahlen 1999). Myopic decision making has been studied in a variety of settings relevant to operations management, including manipulating inventory levels (Thomas and Zhang 2002), modifying production schedules (Roychowdhury 2006), and postponing or eliminating maintenance, new projects, and R&D expenditures (Bushee 1998, Roychowdhury 2006). Furthermore, recent empirical studies indicate that such behavior can be detrimental to the value of the firm in the long term (Holden and Lundstrum 2009, Cohen and Zarowin 2010, Zhao et al. 2012).

Myopic decision making appears to be relatively common. In a survey of over 400 financial executives, Graham et al. (2005) found that 78 percent would sacrifice economic value in order to hit a short-term earnings target. Bruns and Merchant (1990) report that 57 percent of survey respondents consider it ethical to manage short-term earnings by changing or manipulating operating decisions or procedures, and that managers generally prefer operational manipulations over accounting manipulations to meet performance benchmarks. The implications of myopic decision making may take time to be reflected in the firm's stock price. One explanation for this timing difference is that improvements to operational performance are not always motivated by myopic interests and it can be difficult for investors to contemporaneously differentiate between those intended to manipulate short-term performance and those that are optimal for the firm's long-term performance (Schmidt et al. 2012). The potential adverse consequences of myopic operational decisions may therefore not reveal themselves until something goes awry, such as the occurrence of a disruption.

We attempt to shed light on whether or not improvements to performance are perceived by the market as damaging a firm's resiliency by examining the moderating effect of a firm's rate of change in operating performance for internal disruptions. Since internal disruptions occur in areas that are more directly under the firm's control, a firm which has recently improved its operating performance and subsequently experiences an internal disruption may raise concerns among investors that such

improvements contributed to the occurrence of the disruption. Investors may therefore doubt the firm's future performance potential. This aligns with the efficiency-resiliency tradeoff argument proposed in the literature, and leads to the following hypothesis:

Hypothesis 3. *Among firms that experience an internal disruption, those with higher prior rates of operating performance improvement will incur larger reductions in firm value.*

In contrast, lean manufacturing principles support the notion that improvements to operational performance may benefit the firm's resiliency to a disruption. For example, an operationally efficient firm may be able to recognize the supply-chain impact of a disruption more quickly than an operationally inefficient firm, and therefore take appropriate counter-measures sooner (Craighead et al. 2007). We examine this effect by examining whether the impact of an external disruption is moderated by recent rate of change in the firm's operational performance. Unlike internal disruptions, external disruptions may reasonably be considered a random occurrence unrelated to changes in the firm's operating performance, such that the efficiency-at-the-cost-of-resiliency effect used to justify Hypothesis 3 is small or nonexistent. For an external disruption, the argument that efficiency improvements strengthen a firm's resiliency may dominate. For these reasons, we hypothesize:

Hypothesis 4. *Higher prior rates of operating performance improvement will aggravate the impact on firm value of internal disruptions more so than of external disruptions.*

4 Data and Research Setting

4.1 The Sample

We define a disruption as an unplanned event that adversely affects a firm's normal operations. For instance, in a manufacturing environment, disruptions include events such as an unscheduled plant shutdown, a parts shortage, and a transportation interruption. In a retail environment, disruptions include events such as supplier and logistics failures. We identify disruptions by reviewing company press releases distributed via the PRNewswire and Business Wire. According to interviews with managers at public-relations agencies and news outlets, the vast majority of press releases from

publicly traded U.S. companies are distributed through these providers. These managers also confirm that companies typically announce operational issues via a press release and that when a company utilizes multiple information channels, a press release is among those channels.

We apply a search string to the Factiva database of press releases from January 1, 1998, until December 31, 2011. This search string identifies announcements in which the headline or lead paragraph includes such terms as *delay, disruption, interruption, shortage*, or *problem* within 5 words of terms like *component, delivery, parts, shipment, manufacturing, production*, or *operations*. Of the approximately 5.5 million press releases in the Factiva database during our study period, the search string returns approximately 6,900 press releases. We manually reviewed these announcements for relevance. Common reasons why press releases were disqualified in the manual-review stage include that they did not pertain to an actual disruption or pertained to a previously announced disruption. The manual review process yielded 615 press releases representing the first announcement of an actual disruption. From this set of 615 press releases, we linked 517 of them to 412 publicly traded U.S. firms with the requisite stock price and financial information during the study period. Characteristics of the disruption announcements are reported in Table 1.

Approximately one-third of the disruption announcements include earnings information in the form of updated earnings forecasts or full earnings releases. Simply dropping those announcements that contain contemporaneous earnings information may distort the measured impact on firm value of disruptions. Instead, we seek to use this additional information to examine the impact on firm value of disruptions which exceeds their effect through earnings. In addition, this information allows us to control for the fact that some types of disruptions are simply larger than other types of disruptions, which is particularly important in our tests of Hypotheses 2, 3,and 4. So that we can robustly control for the impact of earnings information on firm value, we augment each disruption announcement with announcements of that firm's quarterly financial performance for one year before and one year after the disruption date. The final data set includes 3,406 earnings-only announcements, resulting in a total of 3,923 announcement observations.

4.2 Measures

Descriptions of the variables used in the analysis appear in Table 2. Table 3 provides correlations and Table 4 provides summary statistics.

4.2.1 Characteristics of the Announcement

From each announcement we extract the company name, company identifying information, announcement date, earnings information (if provided), and the source of the disruption (for disruption-related announcements). We classify the source of the disruption as either *internal* or *external* to the firm and its supply chain. Disruptions are classified as internal to the firm and its supply chain if the disruption is attributed in the announcement to either the firm or its suppliers, including inbound and outbound logistics. Disruptions are classified as external to the firm and its supply chain if it is attributed to such outside factors as weather, government regulations, natural disasters, and political turmoil. We classify both firm- and supplier-related disruptions as internal disruptions for three reasons. First, in discussions with operations and supply-chain executives we learned that close relationships between firms and their suppliers often make it difficult to attribute disruptions entirely to the firm or entirely to its supply chain partners. Second, it is not always obvious from the announcements whether the root cause of a disruption is the firm or the firm's supply chain, either because of vague wording or because the firm chose not to or could not make an accurate attribution. Third, as a robustness test we re-ran the analysis by classifying firm- and supplier-attributed disruptions separately and using multiple classifications when there was ambiguity. As discussed in Section 6, we find no evidence of a difference between disruptions attributed to factors internal to the firm and those attributed to factors internal to the firm's supply chain.

In our model we use the enforcement date of Section 409 (Real Time Disclosure) of SOX as an exogenous policy shock to examine whether managers exert bias in announcing material disruptions. Section 409 stipulates that a company must disclose "on a rapid and current Company basis such additional information concerning material changes in its financial condition or operations" (Securities Exchange Commission 2002). The Securities and Exchange Commission (SEC) began enforcing Section 409 on August 23, 2004. We capture this with a dummy variable, *Pre-SOX*, that is coded to "1" for announcements occurring before August 23, 2004 and "0" otherwise.

To examine whether the enforcement of SOX led to a change in the number of of disruption announcements, we create a dummy variable, *Post-SOX Quarter*, that is coded to "1" to identify calendar quarters after August 23, 2004 and "0" otherwise. We also create two counter variables, *Pre-SOX Trend* and *Post-SOX Trend*, that count the number of elapsed quarters in pre- and post-enforcement periods.

4.2.2 Abnormal Return

We calculate the dependent variable, *Abnormal Return*, using an event study. This type of study compares the actual return of the firm's stock with an estimate of the return that would have been realized had the announced disruption not occurred. We collect daily stock-market returns for each company in the data set using the Center for Research in Security Prices (CRSP) database. We generate the counterfactual estimate using the market returns model summarized below and described in greater detail in MacKinlay (1997) and McWilliams and Siegel (1997). The market returns model expresses normal returns of firm i on day t as

$$R_{it} = \eta_i + \theta_i R_t + \epsilon_{it}. \tag{1}$$

R_{it} is the stock return on day t for firm i making the announcement of interest, and R_t is the market return on day t using a value-weighted portfolio of all stocks traded on the NYSE, AMEX, and NASDAQ. Day t is measured relative to the announcement date, which is denoted as day 0, and is the first day the stock market can respond to the announcement. Thus the announcement date is the day the announcement is made, if it occurs either before the U.S. stock markets open or while the markets are open; otherwise the announcement date is the following trading day.

To estimate Equation (1) we use ordinary least squares (OLS) with a benchmark period of 250 trading days (or approximately 1 year), ending 10 days prior to the announcement, i.e. $t = -260, -259, \ldots, -11$. This generates estimated values $\hat{\eta}_i$ and $\hat{\theta}_i$. We then apply these coefficients to actual market-return data in a short event window surrounding the announcement to generate counterfactual estimates of the returns for each stock under the alternative state in which the announcement did not occur. Abnormal returns for the event window are calculated as $\textit{Abnormal Return}_i = \sum_t \textit{Abnormal Return}_{it}$, where $\textit{Abnormal Return}_{it} = R_{it} - (\hat{\eta}_i + \hat{\theta}_i R_t)$ and $\hat{\eta}_i + \hat{\theta}_i R_t$ is the counterfactual expected return for firm i on day t. $\textit{Abnormal Return}_i$ (or simply *Abnormal Return* when the context is clear), is calculated by summing the abnormal returns over the desired number of trading days in the event window. In order to isolate the effect of the announcement, we focus on a 2-day event window (days 0 and 1), but run robustness checks with 3-day (days -1, 0, and 1) and 5-day (days -2, -1, 0, 1, and 2) event windows; the results are not meaningfully different.

4.2.3 Operating Performance Rate of Change

We collect quarterly and annual financial-statement data from Standard and Poor's COMPUSTAT database. From this we create three measures of firm operating performance – return on assets is calculated as net income divided by average total assets, operating margin is calculated as operating income divided by sales, and gross margin is calculated as sales minus the cost of goods sold divided by sales. These ratios are commonly employed to measure firm operating profitability (Brealey et al. 2011).

From these operating performance ratios we create three measures of the rate of change in firm operating performance: the normalized rates of change in return on assets (*ROA Rate*), operating margin (*OM Rate*), and gross margin (*GM Rate*). These rate-of-change measures must be robust to possible changes in sign of the component financial ratio from one quarter to the next, as well as to values in the denominator that can be zero or very close to zero. We thus utilize a normalized rate-of-change measure, which is calculated as the component financial ratio one quarter prior minus the component financial ratio two quarters prior divided by the absolute value of the component financial ratio one quarter prior plus the absolute value of the component financial ratio two quarters prior.[1] The result is a normalized rate-of-change measure that is continuous from -1 to +1, with a negative sign indicating worsening performance and a positive sign indicating improving performance.

4.2.4 Controls

We gather additional firm financial information, such as the book value of equity, long-term debt, and the market value of equity from COMPUSTAT, and calculate one-quarter lagged values for *Fixed Asset Ratio*, *Market-to-Book Ratio*, *Debt-to-Equity Ratio*, and *Log Sales*. In order to determine whether a given announcement results in an unexpected impact on earnings, we collect analysts' earnings forecasts for each company from the Institutional Brokers' Estimate System (I/B/E/S) database. We calculate the variable *Earnings Surprise* as the quarterly earnings per share provided in the announcement minus the average of the analysts' forecast for earnings per share prior to the announcement, divided by the stock price ten days prior to the announcement.

[1] For instance, the normalized rate of change operating margin is $OM\ Rate = \frac{Operating\ Margin_{-1} - Operating\ Margin_{-2}}{|Operating\ Margin_{-1}| + |Operating\ Margin_{-2}|}$, where a subscript of -1 indicates a one-quarter lag and -2 indicates a two-quarter lag.

Because there are some extreme outliers for *Earnings Surprise*, we winsorize it at 5%. As detailed in Section 6, our findings are robust if we do not winsorize *Earnings Surprise*.

4.3 Empirical Models

4.3.1 Management Discretion in Announcing Disruptions

We determine whether there is a difference in the number of announced disruptions before versus after the enforcement date of SEC Section 409 by estimating the following model:

$$\begin{aligned} \textit{Disruption Count}_j = &\alpha + \zeta_1 \cdot \textit{Post-SOX Quarter}_j + \zeta_2 \cdot \textit{Pre-SOX Trend}_j + \\ &\zeta_3 \cdot \textit{Post-SOX Trend}_j + \xi \cdot \textit{Quarter} + \epsilon_j, \end{aligned} \tag{2}$$

where subscript j denotes the calendar quarter-year, *Disruption Count* is a count of the number of disruptions announced during the quarter-year, *Post-SOX Quarter* is a dummy variable which is set to "1" for quarters after the enforcement date of Section 409 of SOX, *Pre-SOX Trend* is a rolling count of the quarters in the pre-enforcement period, and *Post-SOX Trend* is a rolling count of the quarters in the post-enforcement period. The latter two variables control for a linear time trend in the number of quarterly disruption announcements prior and after the enforcement of Section 409. We account for a seasonal trend in the number of announcements per quarter by including a complete set of quarter dummies, *Quarter*, in the specification.

We evaluate whether managers disproportionately under-report disruptions that are more (or less) damaging to firm value by estimating the following model:

$$\begin{aligned} \textit{AbnormalReturn}_i = &\beta_1 \cdot \textit{Disruption}_i + \beta_2 \cdot \textit{Pre-SOX}_i + \beta_3 \cdot \textit{Disruption}_i \times \textit{Pre-SOX}_i + \\ &\gamma' X_i + \xi \cdot Year + \epsilon_i, \end{aligned} \tag{3}$$

where subscript i denotes the announcement, *Disruption* is a dummy variable set to "1" if the announcement pertains to a disruption, *Pre-SOX* is a dummy variable set to "1" if the announcement is made prior to enforcement of Section 409 of SOX, $Year$ is a complete set of year dummies, and the vector X_i includes control variables: *Earnings Surprise*, *Fixed Asset Ratio*, *Market-to-Book Ratio*, *Debt-to-Equity Ratio*, and *Log Sales*. In addition to including several surrounding quarterly financial-performance announcements in the sample, we control for the potentially confounding effect of a firm providing earnings or updated earnings guidance in conjunction with a disruption announcement by including *Earnings Surprise* as a control in the specification. Doing so allows us

to explore whether the effect of a disruption on the firm's stock price is explained by concurrent earnings information, or, alternatively, whether the effect is above and beyond the announced impact on earnings. Since each firm is now represented in the sample by multiple announcements, some of which are disruption announcements and some of which are earnings announcements, we include firm fixed effects to absorb the average firm-specific effects of announcements on *Abnormal Return*.

4.3.2 Attributing Disruptions to Internal or External Factors

To compare the effects of internal and external disruptions, we modify the model in Equation (3) by replacing *Disruption* with *Internal Disruption* and *External Disruption*, and interacting these variables with *Pre-SOX*. *Internal Disruption* identifies disruptions attributed to factors internal to the firm or its supply chain and *External Disruption* identifies disruptions attributed to external factors.

4.3.3 The Moderating Effect of the Rate of Change in Operating Performance

To examine the moderating effect of the rate of change in operating performance, we further modify the model in Equation (3) to create three models of the form:

$$\begin{aligned} AbnormalReturn_i = &\beta_4 \cdot Internal\ Disruption_i + \beta_5 \cdot External\ Disruption_i + \\ &\beta_6 \cdot Pre\text{-}SOX_i + \beta_7 \cdot Internal\ Disruption_i \times Pre\text{-}SOX_i + \\ &\beta_8 \cdot External\ Disruption_i \times Pre\text{-}SOX_i + \\ &\beta_9 \cdot Mod_i + \beta_{10} \cdot Internal\ Disruption_i \times Mod_i + \\ &\beta_{11} \cdot External\ Disruption_i \times Mod_i + \gamma' X_i + \xi \cdot Year + \epsilon_i, \end{aligned} \tag{4}$$

where Mod represents each operating performance rate-of-change metric used in the analysis, namely *ROA Rate*, *OM Rate*, and *GM Rate*.

5 Results

We estimate the model in Equation (2) using a Poisson regression with robust standard errors. We estimate all other models using OLS with firm-level fixed effects and robust standard errors

clustered by firm to account for potential heteroscedasticity and correlation among each firm's announcements over time. Tables 5, 7, and 8 report the results of the tests of our hypotheses.

5.1 Management Discretion in Announcing Disruptions

To evaluate whether or not managers announce all material disruptions, we run a Poisson regression to estimate the specification in Equation (2). The results are presented in Table 5. After the enforcement date, executives have less discretion to decide whether to announce relevant operational disruptions. This provides us with an exogenous policy shock with which to evaluate whether managers had previously been disproportionately under-reporting disruptions that are material under the rubric of SOX. If managers have been reporting fewer disruptions and if SOX attenuates this practice, we expect to observe more disruptions after Section 409 enforcement begins. The coefficient on *Post-SOX Quarter* is 0.52 (SE 0.184, $p < 0.01$), which is equivalent to an increase of 68% in the average number of announced disruptions per quarter after the enforcement date of Section 409. The average marginal effect of *Post-SOX Quarter* is 4.9 additional announced disruptions per quarter in the post-enforcement period compared to the pre-enforcement period. We get similar results by simply running a Welch's t-test to compare the average number of quarterly disruptions in the pre- and post-enforcement periods. The average of 11.2 quarterly disruptions in the post-enforcement time period is statistically significantly larger than the average of 7.5 quarterly disruptions in the pre-enforcement time period (t value 2.86, $p < 0.01$). These tests provide evidence that managers previously underreported disruptions and that this behavior changed in the aftermath of SOX Section 409 enforcement.

The impact of the enforcement of Section 409 is clearly visible in Table 6, which displays the number of announced disruptions in the quarters immediately surrounding the enforcement date. In the quarter that enforcement began there are 17 disruption announcements, 6 of which occurred in the 53 days prior to enforcement and 11 of which occurred in the 39 days after enforcement. In the Poisson regression and Welch's t-test we split this quarter into two periods (a pre-enforcement quarter and a post-enforcement quarter) and gross up the number of announcements based on the number of days in each split period. There is no material difference in the results if we instead drop this quarter from the analysis.

To evaluate whether managers were disproportionately underreporting disruptions that were

more or less damaging to firm value before the SEC began enforcing Section 409 we estimate the specification in Equation (3). The results are presented in column 1 of Table 7. If in the pre-enforcement period managers disproportionately under-reported disruptions that were less (more) damaging to firm value, we expect to observe that the average impact of a disruption on firm stock price is more (less) damaging during that time. The coefficient on *Disruption* is negative and significant (coefficient -0.029, SE 0.006, $p < 0.01$), as is the coefficient on *Disruption* $\times$ *Pre-SOX* (coefficient -0.046, SE 0.010, $p < 0.01$). The coefficient on the interaction term shows that there is a statistically significant difference in the impact on abnormal returns during the pre- and post-enforcement periods. A negative value on this term indicates that on average the disruptions announced in the pre-enforcement period are more damaging to firm value. This provides support for Hypothesis 1 that in the pre-enforcement period managers under-reported disruptions that were less damaging to firm value and instead reported those that were the most damaging. We discuss an alternative explanations for this result in Section 8.1.

In order to generate results likely to be meaningful in a post-SOX world, the specifications for the remaining analyses include *Pre-SOX* and *Pre-SOX* interacted with the disruption variables. This is done to absorb the impact of managerial discretion in announcing disruptions prior to the Section 409 enforcement date. As we will discuss further in Section 6, we conduct a robustness test with a model that is fully interacted with *Pre-SOX* and find little evidence that the moderating effects of interest vary between the pre-enforcement and post-enforcement periods.

5.2 Attributing Disruptions to Internal Versus External Factors

The second column of regression results in Table 7 examines the effect of an internal disruption, the effect of an external disruption, and whether these effects differ. The coefficient on *Internal Disruption* is negative and statistically significant (coefficient -0.038, SE 0.008, $p < 0.01$). The interpretation of this coefficient is that an internal disruption results in a decrease in the abnormal returns of the firm's stock of 3.8 percentage points. The coefficient on *External Disruption* is also negative but only marginally significant (coefficient -0.011, SE 0.006, $p < 0.10$), providing limited evidence that external disruptions also impact the firm's stock price in the post-enforcement period. The difference between the coefficients on *Internal Disruption* and *External Disruption* is -0.027, and a Wald test indicates that this difference is statistically significant ($F = 7.24$, $p <$

0.01). This supports Hypothesis 2 that internal disruptions are more damaging to firm value than external disruptions in the post-enforcement period. We also consider whether the impact differs in the pre-enforcement period by running a Wald test against a linear combination of the coefficients on *Internal Disruption* plus *Internal Disruption* × *Pre-SOX* versus the coefficients on *External Disruption* plus *External Disruption* × *Pre-SOX*. This yields a statistically significant point estimate of -0.043 ($F = 5.30$, $p < 0.05$), also in support of Hypothesis 2.

5.3 The Moderating Effect of the Rate of Change in Operating Performance

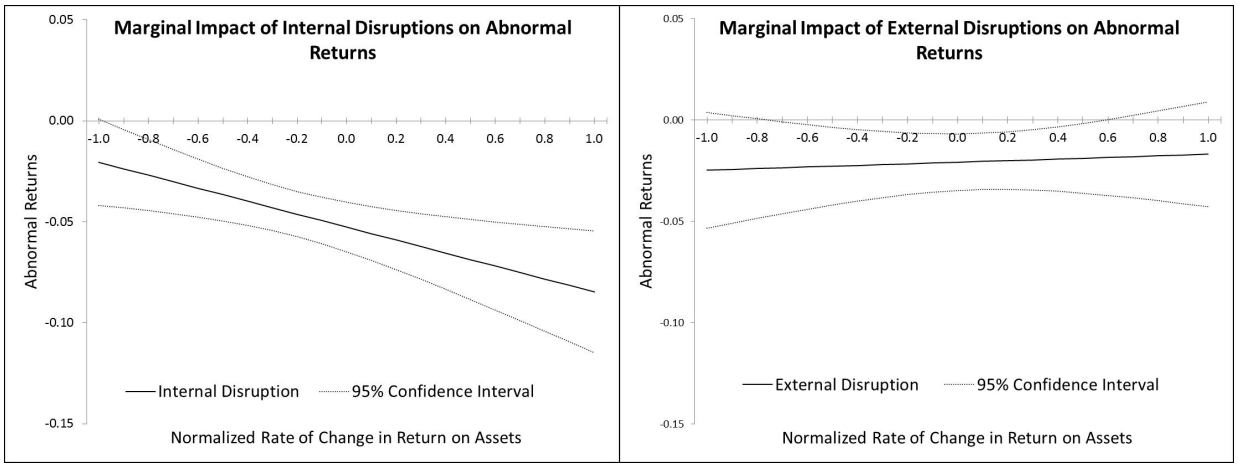
In Table 8 we report our test results on whether the rate of change in operating performance moderates the effect of disruptions on abnormal returns, and whether this effect depends on the type of disruption. In column 1, we consider the rate of change in return on assets. The coefficient on *Internal Disruption* × *ROA Rate* is negative and significant (coefficient -0.032, SE 0.012, $p < 0.01$) and the coefficient on *External Disruption* × *ROA Rate* is positive and insignificant (coefficient 0.004, SE 0.012, $p > 0.10$). A point estimate of the difference between the two coefficients is -0.036 and significant ($F = 4.40$, $p < 0.05$). These tests support Hypotheses 3 and 4 and provide an interesting insight into firm performance improvements. If such improvements are followed by an internal disruption, the negative impact of the disruption on firm value is exacerbated. If such improvements are followed by an external disruption, however, the impact on firm value is smaller.

To gain further insight into how the impact on abnormal returns of internal disruptions differs from that of external returns, we display in Figure 2 the marginal effects of internal and external disruptions on abnormal stock returns across the full value range of values for *ROA Rate*. From Figure 2a it is clear that higher values of *ROA Rate* amplify the negative impact of internal disruptions on abnormal returns and that the marginal affect of internal disruptions is negative and statistically significant over most of the range of *ROA Rate*. Figure 2b, on the other hand, reveals that higher values of *ROA Rate* serve to modestly dampen the negative impact of external disruptions on abnormal returns. In addition, the marginal effect of external disruptions on abnormal stock returns across the range of *ROA Rate* is only slightly negative and often statistically indistinguishable from zero.

Hypotheses 3 and 4 are also supported by the test results displayed in column 2 of Table 8. The coefficient on *Internal Disruption* × *OM Rate* is negative and significant (coefficient -0.039,

Figure 2: The marginal effect on abnormal returns of internal and external disruptions across a range of normalized rates of change in return on assets (*ROA Rate*). 95% confidence intervals are included.

(a) *Internal Disruptions* **(b)** *External Disruptions*



SE 0.014, $p < 0.01$) while coefficient on *External Disruption* × *OM Rate* is positive and insignificant (coefficient 0.006, SE 0.016, $p < 0.01$). A point estimate of the difference between the two coefficients is -0.045 and significant ($F = 4.20$, $p < 0.05$). The marginal effects of internal and external disruptions on abnormal stock returns across a range of values of *OM Rate* looks similar to those in Figure 2. Higher values of *OM Rate* amplify the negative impact of internal disruptions on abnormal returns, decreasing from -0.011 when *OM Rate* is -1 to -0.089 when *OM Rate* is 1, and slightly dampen the negative impact of external disruptions, increasing from -0.026 when *OM Rate* is -1 to -0.014 when *OM Rate* is 1.

Hypothesis 3 is also supported using *GM Rate* as the operating performance rate of change moderator, but Hypothesis 4 is not supported. The coefficient on *Internal Disruption* × *GM Rate* is negative and marginally significant (coefficient -0.046, SE 0.028, $p < 0.10$), and the coefficient on *External Disruption* × *GM Rate* is positive and insignificant (coefficient 0.002, SE 0.063, $p > 0.10$). However, a point estimate of the difference is insignificant (estimate -0.048, $F = 0.47$, $p > 0.10$). These results may be driven by the fact that gross margin can be a very noisy metric, which makes measures that depend on gross margin noisy as well. For instance, compared to the coefficients on *External Disruption* × *ROA Rate* and *External Disruption* × *OM Rate*, the standard error on the coefficient on *External Disruption* × *GM Rate* is quite large.

The results in Table 8 and Figure 2 provide consistent support for Hypothesis 3 and support Hypothesis 4 for the *ROA Rate* and *OM Rate* moderators.

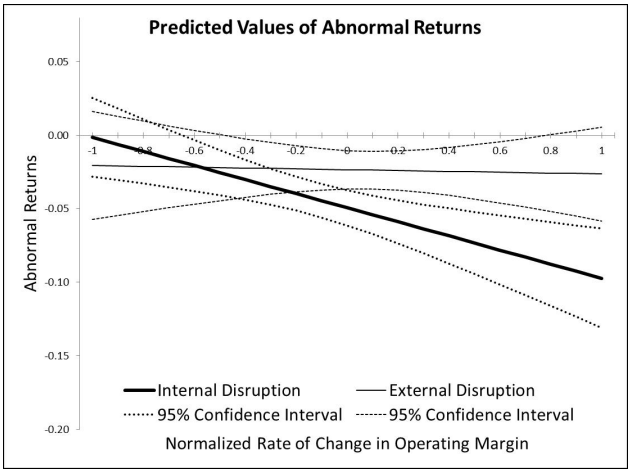
5.4 Economic Implications

We estimate the average impact of a disruption on a firm's abnormal returns to be -7.5 percentage points prior to Section 409 enforcement and -2.9 percentage points after Section 409 enforcement. While both effects are statistically significant, it appears that Section 409 enforcement has tempered managerial discretion in underreporting disruptions that are less damaging but still consequential to the firm's operations under the SOX guidelines.

The impact of a disruption on firm value depends heavily on whether or not the disruption is attributed to factors under the firm's control in both the pre-SOX and post-SOX enforcement period. In the pre-SOX period, the average impact on the firm's stock price of an internal disruption is -7.9 percentage points and -3.6 percentage points for an external disruption. These values are -3.8 percentage points and -1.1 percentage points in the post-SOX period. There are also material differences based on recent rates of change in the firm's operating performance. For instance, if the firm's normalized rate of change in operating margin increases by 0.30 (a unitless measure), the marginal impact of an internal disruption on the firm's stock price is expected to worsen by 1.2 percentage points while the marginal impact of an external disruption on the firm's stock price is expected to improve by 0.2 percentage points. Given that the median daily return for all stocks in the CRSP database from January 1, 1991, until December 31, 2011, is 0.01 percentage points, the results from our analysis are economically significant.

The impact of internal and external disruptions diverges with greater improvements in operating performance. Figure 3 shows the predicted values of *Abnormal Returns* due to internal and external disruptions for a range of normalized rates of change in operating margin (*OM Rate*). As this figure indicates, *Abnormal Returns* between the two types of disruptions are statistically indistinguishable when the normalized rate of change in operating margin is low, and diverge when rate of change in operating margin is high. This indicates that it is improvement rather than deterioration in operating performance that serves to differentiate the impact of these disruption types.

Figure 3: Predicted value of *Abnormal Returns* due to internal and external disruptions across a range of normalized rates of change in operating margin (*OM Rate*). 95% confidence intervals are included.



6 Robustness Checks

6.1 Vulnerability to Outliers

Because some of our financial variables exhibit skew, we run robustness tests after winsorizing the data to ensure that the results are not driven by extreme outliers. Winsorizing contains the impact of outlying data values by replacing those values with values that are at a specified percentile in the data distribution. For instance, winsorizing *Earnings Surprise* at 5 percent involves replacing those values of *Earnings Surprise* that are below the 2.5 percent and above the 97.5 percent tails of the distribution for this variable with values that are at the 2.5 percent and 97.5 percent of the distribution respectively. This data-transformation process is similar to trimming, except that trimming discards the outlying data entirely. Our main findings do not change in any meaningful way for the variables of interest in any of the hypotheses when the financial moderators and financial controls are (1) not winsorized, (2) winsorized at 2.5 percent, or (3) winsorized at 5 percent.

6.2 Do Moderator Effects Change with Section 409 Enforcement?

To assess whether the impact of the operating performance rate-of-change moderators differs in the pre-SOX and post-SOX periods we fully interact each term of the specification in Equation (4) with *Pre-SOX*. If the moderator in the pre-enforcement period differs from that in the post-

enforcement period, either the coefficient on *Internal Disruption* × *Pre-SOX* × *Mod* or the coefficient on *External Disruption* × *Pre-SOX* × *Mod* will be significant. Of the three operating performance rate-of-change moderators examined, there is no instance in which the coefficient on the *Internal Disruption* × *Pre-SOX* × *Mod* term is significant. In addition, in each case the coefficient on *Internal Disruption* × *Mod* remains significant and of similar magnitude as the results presented in Table 8.

There is only one instance in which the coefficient on the *External Disruption* × *Pre-SOX* × *Mod* term is significant, namely *External Disruption* × *Pre-SOX* × *ROA Rate* (coefficient 0.072, SE 0.024, $p < 0.01$). While this does not impact any of our hypothesized results, it does indicate that improvements to operating performance in the pre-enforcement period, at least as measured by return on assets, may alleviate the negative impact of an external disruption. This may provide some evidence of the beneficial effects of operating performance improvement on the firm's ability to respond to disruptions, as suggested by Craighead et al. (2007).

6.3 Do Moderator Effects Differ for Firm Versus Supply Chain Disruptions?

To investigate whether the impact of the operating performance rate-of-change moderators differs depending on whether a disruption is attributed to the firm's internal operations versus its supply chain, we expand the models defined by Equation (4) to use three types of disruptions – (1) internal to the firm, (2) internal to the firm's supply chain, and (3) external to the firm. In the case of ambiguity in the disruption announcement, disruptions are coded to multiple attribution categories. Wald tests indicate that the coefficients on the moderating terms do not significantly differ for disruptions that are internal to the firm versus those that are internal to the firm's supply chain. We also update the model used to generate column 3 of Table 7 with three types of disruptions and find no evidence that the impact of disruptions internal to the firm differs significantly from those that are internal to the firm's supply chain.

6.4 Are the Results Driven by Multiple Disruptions?

Sixty-nine of the 412 firms in our data experience more than one disruption during our study period. To ensure that our results are not driven by firms with multiple disruptions, we update all of our models to include a dummy variable, *Precendent*, that is set to "1" for any disruption

that is not the first for the firm in the data set. Adding this control does not change our results in any meaningful way and the coefficient on this control is consistently small and insignificant in each model.

6.5 Alternative Calculations of *Abnormal Return*

To confirm that our results are not driven by the method we employ to calculate the dependent variable, we run the analysis by instead using 3-day (days -1, 0, and 1) and 5-day (days -2, -1, 0, 1, and 2) event windows and achieve results with similar inferences to those using a 2-day event window.

7 Extensions

7.1 Separating the Short-Term and Long-Term Impact of Disruptions

Including *Earnings Surprise* in the original models serves to partial out the impact of earnings information separately from that of disruptions. We extend our analysis by excluding *Earnings Surprise*, which allows us to approximate the total effect of disruptions, including the impact of the disruption on short-term earnings. The results are substantively similar, which implies that the major driver in determining the impact of a disruption on firm value is its anticipated impact on long-term earning streams rather than the projected impact on short-term earnings.

7.2 Are Disruptions Increasing or Decreasing in Frequency?

The Poisson regression estimates of the specification in Equation (2) provide us with some insight as to whether the number of announced disruptions is increasing or decreasing over time, after controlling for the impact of Section 409 enforcement. These results are presented in Table 5. The coefficient on *Pre-SOX Trend* is negative and significant (coefficient -0.028, SE 0.011, $p < 0.05$) as is the coefficient on the *Post-SOX Trend* (coefficient -0.035, SE 0.007, $p < 0.01$). This indicates that in both the pre- and post-enforcement periods there is a negative time trend in the number of announced disruptions. This negative time trend is entirely masked and instead appears positive and insignificant if *Post-SOX Quarter* is removed from the specification and a single variable *Trend* (coefficient 0.002, SE 0.003, $p > 0.10$) is used in lieu of *Pre-SOX Trend* and *Post-SOX Trend*.

Although we do not rigorously examine this issue in the current paper, this finding indicates that firms are not suffering an increasing number of disruptions, but instead firms are simply disclosing disruptions more reliably.

8 Discussion and Managerial Implications

8.1 The Impact of SOX

We show that disruptions announced prior to the enforcement of Section 409 have a statistically significant and materially larger impact on the abnormal returns of the firm's stock. To better understand the drivers of this phenomenon, we interviewed several current and former executives of publicly traded firms. "[We] would really weigh the pros and cons [of making an announcement], since you don't want to prematurely spook the market," the President of a large supermarket chain acknowledged. The CEO and Chairman of a major electronics component distributor made the same point more colorfully: "Firms will be hesitant to pull their pants down in public unless they are forced to do it." The interviews support the view that, prior to Section 409 enforcement, managers avoided announcing less serious disruptions that may not otherwise be noticed, but felt compelled to announce those that were more serious and perhaps harder to address privately. Post-enforcement announcements, by contrast, include disruptions material enough to warrant disclosure but that might not have otherwise been announced had management retained more discretion.

An alternative explanation for the drop in the impact on firm value of announced disruptions in the post-SOX period is that Section 409 enforcement mitigated some information asymmetry that exacerbated the market's reaction to disruption announcements. However, this explanation does not account for the large increase in the number of disruptions announced after the Section 409 enforcement date. Nor does it explain why managers would not simply self-disclose with greater regularity and avoid the more adverse market reaction. Managerial bias against disclosing less serious but still significant disruptions explains both the reduction in the average effect and the increase in the number of disruption announcements.

Another alternative explanation is that in the post-enforcement period managers began announcing disruptions that they knew to be immaterial. However, under the new disclosure rules managers are not obligated to announce disruptions that they believe to be inconsequential. Recall

that Section 409 only obligates managers to promptly disclose information likely to have a material effect on the firm's financial condition or operations. Based on our discussions with executives it was clear that managers would have little incentive to announce insignificant disruptions, and they would actually be averse to doing so. A more straightforward interpretation of our results is that, prior to Section 409 enforcement, managers simply chose not to announce less damaging disruptions that would have been considered material under the rubric of SOX.

8.2 Rationale for Using Press Releases

We construct our sample using a process that differs from that employed in Hendricks and Singhal (2003) and Hendricks and Singhal (2005b). In these studies, observations are identified by drawing on reports from third-party news agencies like the *Wall Street Journal* and Dow Jones Newswire. We believe that there is ample justification to deviate from this approach in our analysis. In fulfillment of their role as news-reporting agencies, organizations like the *Wall Street Journal* and Dow Jones Newswire report on events that they deem newsworthy. Some types of events are newsworthy by nature, regardless of the circumstances surrounding them. This category includes earnings announcements, leadership changes, and new equity issuances. A news-reporting agency can reasonably be expected to report on most occurrences of such events; that is, the agency is not likely to exercise significant editorial discretion over which occurrences they report. Other event types, however, are not universally newsworthy. In such cases, the news-reporting agency may exercise significant editorial discretion over which occurrences they report. For event studies that use stock returns as the dependent variable, selection bias will be a material problem if the process that the news agency employs to select news events to cover is based on the stock market's actual or anticipated response.

To evaluate whether such selection bias pertains to disruptions, we interviewed reporters on the business desk of the *Wall Street Journal* to determine how they decide which disruptions to cover. It became apparent in these discussions that, as one reporter put it, "If the stock is unmoved [by the disruption], it won't get in the column." These interviews convinced us that because reporters covered disruptions based on the movement or anticipated movement in the firm's stock price, bias would be introduced into any analysis that drew observations from such reports and used stock price as the dependent variable. This bias is aggravated in Hendricks and Singhal (2003) and Hendricks

and Singhal (2005b), which follow a prescribed practice for event studies to include the day before the publication date in the event window (MacKinlay 1997, McWilliams and Siegel 1997). The rationale for doing so is reasonable when limited choice is exerted by the reporting agency: it takes into account the possibility that news of the event leaked to the market prior to publication. But this empirical approach makes selection on the dependent variable particularly problematic when choice is exerted by the reporting agency because the abnormal-returns calculation will include any extreme market responses that influenced the reporting agency to select the story in the first place.

8.3 Managerial Implications

The impact of disruptions on firm value can vary widely, but there are clearly instances when disruptions have a devastating effect. Thus it is important for managers and investors alike to recognize the types of disruptions and the firm characteristics that contribute disproportionately to more undesirable outcomes. Countermeasures to mitigate the risk of disruptions have a cost, and insights into the types of disruptions that represent the greatest risk to company value will help managers assess whether the company is investing appropriately to mitigate the most material risks.

We have shown that the type of disruption matters in identifying the magnitude of a disruption's impact on a firm's share price. Disruptions attributed to factors within the firm or its supply chain are far more damaging than disruptions attributed to external factors. Furthermore, operating performance metrics have different moderating effects on the impact of internal and external disruptions. Higher rates of improvement in operating performance metrics exacerbate the negative impact of internal disruptions but do not affect the impact of external disruptions. As a result of these findings, management should be vigilant about decisions to streamline operations and to reduce buffers and excess capacity if such decisions entail increased disruption risk. Such efficiency improvements may be attractive during periods of relative operational stability, but our analysis indicates that firms with high rates of improvement in operational performance could face distressing reductions in market value if they subsequently experience an internal disruption.

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Table 1: Sample statistics (disruption announcements only)

Year	**Frequency**	**Percent**
1998	42	8.1
1999	35	6.8
2000	33	6.4
2001	30	5.8
2002	22	4.3
2003	16	3.1
2004	45	8.7
2005	70	13.5
2006	38	7.4
2007	36	7.0
2008	69	13.3
2009	24	4.6
2010	32	6.2
2011	25	4.8
Total	517	100.0
Industry	**Frequency**	**Percent**
Food and Tobacco (SIC 2000 - 2199)	15	2.9
Textiles (SIC 2200 - 2399)	10	1.9
Lumber and Furniture (SIC 2400 - 2599)	13	2.5
Paper and Printing (SIC 2600 - 2799)	7	1.4
Chemicals and Petroleum (SIC 2800 - 3099)	91	17.6
Stone and Leather (SIC 3100 - 3299)	3	0.6
Primary and Fab. Metals (SIC 3300 - 3499)	39	7.5
Industrial Machinery (SIC 3500 - 3599)	27	5.2
Electronics (SIC 3600 - 3699)	66	12.8
Transportation Equipment (SIC 3700 - 3799)	30	5.8
Instruments (SIC 3800 - 3899)	43	8.3
Miscellaneous Mfg. (SIC 3900 - 3999)	6	1.2
Transport and Utilities (SIC 4000 - 4999)	26	5.0
Retail and Wholesale (SIC 5000 - 5999)	27	5.2
Finance and Real Estate (SIC 6000 - 6999)	1	0.2
Services(SIC 7000 - 8999)	8	1.5
Other	105	20.3
Total	517	100.0
Current Quarter Sales	**Frequency**	**Percent**
Sales $<$ \$100M	209	40.4
Sales $\geq$ \$100M and $<$ \$500M	150	29.0
Sales $\geq$ \$500M and $<$ \$2B	98	19.0
Sales $\geq$ \$2B	52	10.1
Sales unknown	8	1.5
Total	517	100.0

Table 2: Description of Variables

Variable	Description
Abnormal Return	Excess return on the firm's common stock
Disruption	Indicator identifying an unplanned event that adversely affects a firm's normal operations
Internal Disruption	Indicator identifying a disruption attributed to factors internal to the firm's operations or supply chain
External Disruption	Indicator identifying a disruption attributed to factors external to the firm's operations or supply chain
Pre-SOX	Indicator identifying a disruption occurring on or before the initial enforcement date of the Sarbanes Oxley Act of 2002 (SOX) Section 409, August 23, 2004
ROA Rate	The normalized rate of change in the firm's quarterly return on assets (ROA) over the last two quarters, $\frac{ROA_{-1}-ROA_{-2}}{\lvert ROA_{-1}\rvert+\lvert ROA_{-2}\rvert}$
OM Rate	The normalized rate of change in the firm's quarterly operating margin (OM) over the last two quarters, $\frac{Operating\ Margin_{-1}-Operating\ Margin_{-2}}{\lvert Operating\ Margin_{-1}\rvert+\lvert Operating\ Margin_{-2}\rvert}$
GM Rate	The normalized rate of change in the firm's quarterly gross margin (GM) over the last two quarters, $\frac{Gross\ Margin_{-1}-Gross\ Margin_{-2}}{\lvert Gross\ Margin_{-1}\rvert+\lvert Gross\ Margin_{-2}\rvert}$
Earnings Surprise	The difference between the quarterly earnings per share provided in the announcement and the average of the analysts' forecast for earnings per share prior to the announcement, divided by the stock price ten days prior to the announcement. This value is winsorized at 5%.
Debt-to-Equity Ratio	The book value of the firm's long-term debt divided by market value of its common equity, lagged one quarter
Market-to-Book Ratio	The market value of the firm's common equity divided by the book value of its common equity, lagged one quarter
Fixed Assets Ratio	The ratio of property, plant, and equipment divided by total assets, lagged one quarter
Log Sales	The natural log of quarterly sales (in $M), lagged one quarter
Disruption Count	Count of the number of disruption announcements in each calendar quarter
Post-SOX Quarter	Indicator identifying whether the calendar quarter is before or after the enforcement date of SOX Section 409
Pre-SOX Trend	Counter for the number of elapsed quarters in pre-enforcement period
Post-SOX Trend	Counter for the number of elapsed quarters in post-enforcement period

Note: *A subscript of -1 indicates a one-quarter lag; a subscript of -2 indicates a two-quarter lag. All of the variables are dimensioned by firm, except* Disruption Count*,* Post-SOX Quarter*,* Pre-SOX Trend*, and* Post-SOX Trend *which are dimensioned by the quarter of the disruption.*

Table 3: Correlations

Variables	Abnormal Return	Disruption	Internal Disruption	External Disruption	Pre-SOX	ROA Rate	OM Rate	GM Rate	Earnings Surprise	Debt-to-Equity Ratio	Market-to-Book Ratio	Fixed Assets Ratio	Log Sales
Abnormal Return	1.00												
Disruption	-0.17	1.00											
Internal Disruption	-0.17	0.85	1.00										
External Disruption	-0.04	0.50	-0.01	1.00									
Pre-SOX	-0.03	0.01	0.04	-0.05	1.00								
ROA Rate	-0.04	-0.00	-0.01	0.01	-0.00	1.00							
OM Rate	-0.06	0.02	0.01	0.02	0.01	0.62	1.00						
GM Rate	-0.05	0.01	0.00	0.02	0.01	0.31	0.48	1.00					
Earnings Surprise	0.11	0.03	0.02	0.03	-0.04	0.05	0.05	0.07	1.00				
Debt-to-Equity Ratio	0.06	-0.01	-0.01	-0.02	0.09	0.00	0.01	0.00	-0.07	1.00			
Market-to-Book Ratio	-0.04	0.00	0.00	-0.00	-0.02	0.03	0.04	0.03	0.08	-0.13	1.00		
Fixed Assets Ratio	0.03	-0.02	-0.06	0.05	-0.14	-0.00	0.01	-0.00	0.02	0.18	-0.05	1.00	
Log Sales	0.07	-0.08	-0.10	0.01	-0.29	0.02	0.03	0.00	0.16	0.16	0.05	0.27	1.00

Table 4: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Abnormal Return	-0.009	0.088	-0.689	0.607	3923
Disruption	0.132	0.338	0	1	3923
Internal Disruption	0.098	0.298	0	1	3923
External Disruption	0.036	0.187	0	1	3923
Pre-SOX	0.373	0.484	0	1	3923
ROA Rate	-0.017	0.566	-1	1	3849
OM Rate	-0.008	0.459	-1	1	3780
GM Rate	0.005	0.219	-1	1	3786
Earnings Surprise	-0.003	0.012	-0.048	0.013	3923
Debt-to-Equity Ratio	0.403	0.656	0	4.493	3923
Market-to-Book Ratio	2.877	2.942	0	20.191	3923
Fixed Assets Ratio	0.356	0.245	0	0.895	3923
Log Sales	5.292	2.026	0	11.258	3923

Table 5: The number of announced disruptions per quarter in the pre- and post-enforcement of Section 409.

Dep. Var.: *Disruption Count*	
	(1)
Post-SOX Quarter	0.520**
	[0.184]
Pre-SOX Trend	-0.028*
	[0.011]
Post-SOX Trend	-0.035**
	[0.007]
Quarter2	0.076
	[0.136]
Quarter3	0.287+
	[0.156]
Quarter4	0.309*
	[0.121]
Constant	2.205**
	[0.160]
Quarters	57
Pseudo R^2	0.184

Notes: Poisson regression. Robust standard errors in brackets. ** p<0.01, * p<0.05, + p<0.1

Table 6: The number of announced disruptions in the calendar quarters surrounding the enforcement date (August 23, 2004) of SOX Section 409.

	Pre-Enforcement					***Post-Enforcement***				
	Q3'03	Q4'03	Q1'04	Q2'04	Q3'04 (53 days)	Q3'04 (39 days)	Q4'04	Q1'05	Q2'05	Q3'05
Disruption Count	3	1	7	6	6	11	15	12	14	19

Table 7: The impact of SOX Section 409 enforcement and the differential effect of internal versus external disruptions.

	Dependent Variable: *Abnormal Return*		
		(1)	(2)
	Disruption	-0.029**	
		[0.006]	
	Pre-SOX	-0.007	-0.006
		[0.012]	[0.012]
	Disruption × Pre-SOX	-0.046**	
		[0.010]	
(A)	Internal Disruption		-0.038**
			[0.008]
(B)	External Disruption		-0.011+
			[0.006]
(C)	Internal Disruption × Pre-SOX		-0.041**
			[0.012]
(D)	External Disruption × Pre-SOX		-0.025
			[0.017]
	Earnings Surprise	0.893**	0.895**
		[0.196]	[0.196]
	Debt-to-Equity Ratio	0.013*	0.013*
		[0.006]	[0.005]
	Market-to-Book Ratio	-0.003**	-0.002*
		[0.001]	[0.001]
	Fixed Assets Ratio	-0.028	-0.023
		[0.025]	[0.025]
	Log Sales	-0.009+	-0.009+
		[0.005]	[0.005]
	Announcements	3,923	3,923
	Disruptions	517	517
	Firms	412	412
	R^2	0.060	0.062
	Wald test: Coeff on (A)=(B)?		7.24**
	Wald test: Coeff on (A)+(C)=(B)+(D)?		5.30*

Notes: Ordinary least squares with firm fixed effects. Robust standard errors clustered by firm in brackets. Additional controls include $Year$ dummies. Wald tests report F statistics. ** p<0.01, * p<0.05, + p<0.10

Table 8: Rate of change in operating performance moderating the impact of internal and external disruptions.

		Dependent Variable: *Abnormal Return*		
		(1)	(2)	(3)
(A)	Internal Disruption × ROA Rate	-0.032**		
		[0.012]		
(B)	External Disruption × ROA Rate	0.004		
		[0.012]		
(C)	Internal Disruption × OM Rate		-0.039**	
			[0.014]	
(D)	External Disruption × OM Rate		0.006	
			[0.016]	
(E)	Internal Disruption × GM Rate			-0.046+
				[0.028]
(F)	External Disruption × GM Rate			0.002
				[0.063]
	Return on Assets (ROA) Rate	-0.004+		
		[0.003]		
	Operating Margin (OM) Rate		-0.009*	
			[0.004]	
	Gross Margin (GM) Rate			-0.013+
				[0.007]
	Internal Disruption	-0.039**	-0.036**	-0.036**
		[0.008]	[0.007]	[0.007]
	External Disruption	-0.011+	-0.010	-0.010
		[0.006]	[0.006]	[0.007]
	Pre-SOX	-0.009	-0.008	-0.006
		[0.011]	[0.011]	[0.012]
	Internal Disruption × Pre-SOX	-0.037**	-0.038**	-0.039**
		[0.011]	[0.011]	[0.011]
	External Disruption × Pre-SOX	-0.028	-0.032+	-0.033+
		[0.018]	[0.017]	[0.017]
	Earnings Surprise	0.938**	0.904**	0.916**
		[0.196]	[0.196]	[0.195]
	Announcements	3,849	3,780	3,786
	Disruptions	505	485	487
	Firms	404	396	397
	R^2	0.067	0.069	0.064
	Wald test: Coeff on (A)=(B)?	4.40*		
	Wald test: Coeff on (C)=(D)?		4.20*	
	Wald test: Coeff on (E)=(F)?			0.47

Notes: Ordinary least squares with firm fixed effects. Robust standard errors clustered by firm in brackets. Additional controls include *Year* dummies, *Debt-to-Equity Ratio*, *Market-to-Book Ratio*, *Fixed Assets Ratio*, and *Log Sales*. Wald tests report F statistics. ** p<0.01, * p<0.05, + p<0.10